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BIOMAGNETISM: AN ANNOTATED BIBLIOGRAPHY

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PREFACE

This bibliography consists of 161 annotated references on the subject of the biological effects of magnetic fields. The publications cited cover a period from 1967 through 1971. The references include research on plants, animals and humans exposed to field strengths ranging from null through geomagnetic, low, and high intensities. Variations in field orientation, exposure time and field gradient are noted where possible. Applications relevant to spaceflight are included; clinical observations and therapeutic applications are also noted.

The abstracts are arranged alphabetically according to the last name of the first author and then chronologically for each of the author's publications. Subject and author indexes follow the text. Indexing was done from the abstracted literature. In the subject index, reference to the type of response of the biological object to the magnetic stimulus and the biological mechanism of the magnetic effect are indicated by italics.

Earlier bibliographies on research in the area of biomagnetics which may be of interest to the reader include:

Busby, D.E. 1967
Biomagnetics. Considerations Relevant to Manned Space Flight. National Aeronautics and Space Administration, Washington, D.C., NASA-CR-889, 63 pages.

Davis, L.D., K. Pappajohn and I.M. Plavnieks. 1962.
Bibliography of the biological effects of magnetic fields. Fed. Proc. 21(5, Part II):1-38.

Gross, L. 1964.
Bibliography of the biological effects of static magnetic fields. In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields. Plenum Press, New York. p. 297-311.

The author gratefully acknowledges the suggestions of Mrs. Jean Pulliam in processing the bibliography and the preparation of the text by Mrs. Bobbie Allen.

TABLE OF CONTENTS

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ANNOTATED BIBLIOGRAPHY

1. AMER, N.M. 1967.
Effects of homogeneous magnetic fields upon biological systems.
In: Joint NASA-AEC Program in Space Radiation Biology. California Univ., Berkeley, Lawrence Radiation Lab. p. 25-28. Sep.

The hypothesis that homogeneous magnetic fields effect the development of *Tribolium confusum*, in a manner quantitatively equivalent to an intrinsic cooling effect of the order of 1°C/6000 gauss was tested with substances having mesomorphic states. Light-scattering properties change as a function of temperature. At a mesomorphic state with a range of coloration between 34° and 37°C at an ambient temperature of 37°C ± 0.1°, an external magnetic field of 6.3 kG was applied to the preparation. A gradual change in the wavelength of the scattered light was shifted from 4600 to 6200 Å. (A.L.)

2. BARBIERI, M., A.F. VALENTINI, Q. ZINI, and O.M. OLIVO. 1970.
Effetti del campo magnetico sulle colture di fibroblasti *in vitro*. [Effects of the magnetic field on culture of fibroblasts *in vitro*.]
Boll. Soc. Ital. Biol. Sper. 46:762-766. 30 Sep.

A study was undertaken to determine if the action of the magnetic field provoked morphological and functional modifications important to normal histophysiological investigation. Embryonal chicken heart cultures were used in this study. After exposure to a vertical homogeneous magnetic field of 5,000 to 6,000 oersted, or a dishomogeneous vertical field of 6,000 to 7,000 oersted, or a dishomogeneous horizontal field of 3,000 to 3,500 oersted, for one-half, one, 12, or 24 hours, the preparations were fixed and stained. Results from 134 cultures are shown in tables. It appears that the magnetic field exerts two distinct effects on the dynamics of cellular proliferation: first, a slowing of various processes concerned with karyokinesis; and, second, a probable effect of the interkinetic cell in the synthesis of DNA. The magnetic field does not impede the fulfillment of mitosis of the cell from the end of DNA synthesis to the beginning of mitosis. Various hypotheses of magnetic field effects on mitosis are discussed. (A.R.T.)

3. BARNES, E.B. 1967.
Biomagnetic Mechanisms.
University of Michigan, University Microfilms, no. 68-7853, 83 pages.

The velocities of the reaction $Zn/CuSO_4$ were investigated in uniform magnetic fields. The reaction velocities in magnetic fields were found to be increased over the control velocities. It was observed that the reaction velocities were a function of field strengths. Orientation of the reacting surface with respect to the field was found not to influence the effect of the field on the reaction velocities. The effects of uniform and non-uniform magnetic fields on the rate of exudation of sap from the stems of young tomato plants were investigated to determine whether a biomagnetic effect could be detected. It was found that the rate of exudation of xylem sap was reduced both in uniform and non-uniform fields. A mechanism for the effect of the Earth's magnetic field on the normal environment of biological systems is presented. (A.L.)

4. BARNOTHY, M.F., ed. 1969.
Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. 314 pages.

This book covers a wide area of research, both with respect to the strength of the electromagnetic field, ranging from "zero" to 150,000 oersteds, and with respect to the various specimens and their biological functions. The first chapter discusses various types of commercially available magnets and defines the terms and units used. The second chapter contains a short resume of investigations performed in low magnetic fields. Some common aspects of biomagnetic effects that emerge from a review of the experimental material collected in the remaining 17 chapters of the book include: 1) the existence of a threshold field strength; 2) the persistence of many effects for long periods of time; 3) the mobilization of regenerative processes by a magnetic stimulus; 4) the alteration of oxidative processes in a magnetic field; 5) the nature of the electrical conduction of the central nervous system; 6) the change in the activity of enzyme-substrate systems at high fields and in "zero" fields; and, 7) the effects of magnetic fields on embryonic development. The last chapter discusses the magnetic susceptibility of biological materials. (A.R.T.)

5. BARNOTHY, M.F., and I. SUEMEGI. 1969.
Effects of the magnetic field on internal organs and the endocrine system of mice.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 103-126.

In three experiments using homogeneous magnetic fields morphological changes in mouse organs were examined to determine if magnetic fields induced a stress response. In experiment I,

20 ten week old random-bred Swiss female mice were exposed to a field of 4200 Oe for 35 days and killed 196 days post exposure. Experiment II used 47 day old, random-bred, male Swiss mice in a 9800 Oe field for either 13 days or 4 days with sacrifice immediately after termination of exposure. In experiment III two male-female pairs of C_3H inbred mice were mated and two generations were born under a 2200 Oe field; the treatment time was 40 days, of which 20 days were prenatal exposure. The 4200 Oe field produced in 78% of the mice a disorganization of more than one half of the zona fasciculata of the adrenal gland. The same severity of lesions was shown in 70% of the animals at 9800 Oe and in 80% of the first generation and 50% of the second generation exposed to 2200 Oe. In all three experiments the number of megakaryocytes decreased significantly in the bone marrow. An increase in both the number of megakaryocytes in the spleens and in the mitotic indexes of the livers of the magnet-group occurred in experiments I and II but not in III. While some of the observed abnormalities are seen when an organism is subjected to any stress, distinct variations due to magnetic stress were noted. (L.M.)

6. BARNOTHY, M.F., and J.M. BARNOTHY. 1970.
Magnetic fields and the number of blood platelets.
Nature (London) 225:1146-1147. 21 Mar.

Female virgin DBA/J2 strain mice, 100-120 days old, were placed in a 9,000 oersted homogeneous, vertical magnetic field for 20 days. Blood was taken every 3-6 days from the tail vein of each mouse. The mice kept in the magnetic field showed, as early as the third day of their exposure to the field, a 25 ± 3% increase in the number of platelets over the value of their controls. From the tenth to the last day of their residence in the field, the difference between the magnet and the control groups vanished. The observed variation in the number of platelets could be interpreted as a reaction of the organism to the stress of the magnetic field. After removal of the mice from the magnetic field an increase of the platelet number was again observed. Further investigations are needed to clarify whether the magnetic field merely changes the number of blood platelets, or whether it also produces morphological alterations in them. (L.M.)

7. BECKER, G. 1971.
Magnetfeld-Einfluss auf die Galeriebau-Richtung bei Termiten.
[The effect of a magnetic field on the gallery building direction of termites.]
Naturwissenschaften 58(1):60.

Most termite species build protective connecting paths between nest and nourishment which are called galleries. For some

species, there has been a tendency for these galleries to be oriented in North-South and East-West directions. The role of the Earth's magnetic field in accounting for this phenomenon, was studied by observing the direction of gallery building in a cylindrical patch of earth with wood at the periphery. The magnetic field produced statistically significant orientation effects which could be confirmed both by changing the orientation of the field and by shielding the magnetic field with a copper Faraday cage. The magnetic field influenced the work of not just a single animal, but of a population of animals who are almost continually in motion. Other constantly changing electromagnetic and physical factors in the environment may also influence gallery direction but these have not yet been analyzed. (T.P.U.)

8. BECKER, R.O. 1969.
The effect of magnetic fields upon the central nervous system.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields. Vol. 2.
Plenum Press, New York. p. 207-214.

Recent literature on biomagnetism is briefly reviewed and an attempt is made to determine the basis for the interaction between neural structures and magnetic fields. Low-field strengths are apparently productive of subtle behavioral alterations without demonstrable effects upon the measurable electrical activity, while high-strength fields are related to observable alterations in electrical activity. Evidence indicates that a vectorial relationship exists between the field direction and the neuraxis; the geomagnetic field appears to effect the functioning of higher neuronal centers. In attempting to determine the actual mode of action of the magnetic field on neural structures, it is noted that the bulk of observations reported indicate an interaction between the applied magnetic field and some active functional property of the central nervous system (CNS). Certain aspects of the DC potentials of nerve tissue indicate their possible role as the target mechanism. Evidence has been attained that this DC system is based upon some solid-state, possibly semiconduction, property of the tissue organization generating and transmitting the steady-state potentials which exerts a regulatory effect upon the overall functioning of the CNS and is, at the same time, acutely sensitive to applied magnetic fields. (A.R.T.)

9. BEISCHER, D.E., E.F. MILLER, II, and J.C. KNEPTON, JR. 1967.
Exposure of man to low intensity magnetic fields in a coil system.
Naval School of Aviation Medicine, Pensacola, Fla. 31 pages.
3 Oct. NASA-CR-90223

The magnetosphere is an intrinsic component of the earth environment, and travel beyond this sphere will expose man to near absence of a magnetic field. The present study is a continuation of a previous investigation of the physiological and psychological effects of prolonged exposure of man to low intensity magnetic fields. In support of previous findings, a significant gradual decrease of the scotopic flicker fusion threshold was observed from which the subjects recovered after exposure. Problems of life in a magnetic field-free environment are discussed. (Author)

10. BEISCHER, D.E. 1969.
Vectorcardiogram and aortic blood flow of squirrel monkeys (*Saimiri sciureus*) in a strong superconductive electromagnet.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 241-259.

Vectorcardiograms of squirrel monkeys subjected to a superconductive magnet with high field strength were studied. The study furnished much stronger and clearer signals regarding the increase in the T-wave amplitude of the ECG than those of previous studies. The observed increase of the T-wave has been confirmed to be a superimposition on the ECG of the emf generated by blood flow. The magnetic method provides, in a single record, information on the electrical and mechanical activity of the heart and represents a new, noninvasive method of studying cardiac performance. (A.L.)

11. BEISCHER, D.E., and G.S. COWART. 1970.
Growth of *Staphylococcus aureus* in a null magnetic field environment.
U.S. Nav. Aerosp. Med. Inst. NAMI 1105:1-7.

No significant differences were observed between the growth of *S. aureus* in the geomagnetic field or in a magnetic field with a field strength reduced by a factor of 1000. Pigmentation, mannitol fermentation, gelatinase activity, coagulase production and catalase activity were not influenced by the low magnetic field. The results are discussed in their relation to previously reported findings on the reduction of growth rate in fields weaker than the geomagnetic field. (Author)

12. BENNETT, M.F., and J. HUGUENIN. 1969.
Geomagnetic effects on a circadian difference in reaction times in earthworms.
Z. Vergl. Physiol. 63(4):440-445.

The effect of the geomagnetic field on the light-withdrawal reflex of earthworms, *Lumbricus terrestris L.*, was investigated during the autumn of 1968. The reactions of worms kept in the Earth's magnetic field were timed, beginning at 12:00 and at 20:00 eastern standard time, on each of 63 days; the same was done for worms maintained in a field whose intensity was essentially zero. The worms in the Earth's field withdrew from light significantly faster at night than at midday. No significant difference between the mean reaction times at 12:00 and those of the evening were found for the animals in the greatly reduced magnetic field. Geomagnetism does have some effect on the circadian difference in reaction rates in this species. (Author)

13. BLACK, D.I. 1967.
Cosmic ray effects and faunal extinctions at geomagnetic field reversals.
Earth Planet. Sci. Lett. 3(3):225-236.

Studies of deep-sea cores show that the last reversal of the Earth's magnetic field and the extinction of a group of radiolarian species occurred simultaneously: the evidence suggests a possible causal relation. Some effects on the Earth and atmosphere at a field reversal are quantitatively considered, but it is shown that no direct or indirect radiation effect from cosmic rays or solar flares, nor any solar wind effect, can be a significant factor in the extinction of the species. The grounds for believing in a causal relationship between magnetic and faunal changes are examined. (R.C.J.)

14. BOE, A.A., J.Y. DO, and D.K. SALUNKHE. 1968.
Tomato ripening: effects of light frequency, magnetic field, and chemical treatments.
Econ. Bot. 22(2):124-134.

Mature, uncolored, field grown fruit were exposed to various treatments to determine the most effective method for controlling fruit ripening. The temperature for all treatments was 21°C. Magnetic field with flux density of 600 gauss was used. Cellophane filters were used to produce green light at 43 foot candles; blue at 47; red at 37; far red at 30. The chemical solutions, injected into one locule, were: EtOH 25 and 50%; glucose and fructose 25%; pyruvic, citric, and malic acids 1%; and AcH 5 ppm. Fruit was immersed in solutions of: 2,4-D, 2,4,5-T, or naphthaleneacetic acid (NAA) at 1000 ppm.; EtOH 10%; hexyl, heptyl, octyl, dedecyl, or hexadecyl alcohol at 1%; and kinetin at 10 ppm. The magnetic field increased the rate of ripening because of increased synthesis of carotenoids, β-carotene, and lycopene. All light treatment, ex-

cept far red, increased the respiration rate after 5-8 days above the control. Ripening was also hastened by EtOH, hexyl alcohol, 2,4-D, NAA, and kinetin. The other chemicals injured the fruit. The organic acids were practically without effect. (J.J.W.)

15. BOGINICH, L.F. 1971.
Vliyaniye peremennogo magnitnogo polya na fagotsitoz. [The effect of indirect magnetic fields on phagocytosis.]
Zh. Mikrobiol. Epidemiol. Immunobiol. 4:141-142. Apr.

The purpose was designed to study the dynamics of phagocytic activity of leucocytes under conditions of extended and continuous exposure to a variable magnetic field (20 oersted, 50 Hz). The studies, performed with 128 white rats, were limited to calculation of the indicators of absorptive and digestive capacity of the neutrophils. The absorptive capacity of leucocytes increases during the first 48 hours, the increase being nearly statistically reliable after the first 12 hours. By the third day, a statistically reliable decrease occurs. Beginning with the fifth day differences between the experimental and control groups practically disappear. The dynamics of digestive capacity are slightly different. During the first 48 hours, a statistically reliable increase was noted (27-64% greater than in the control group). By the third day, the difference was negligible. A new increase in digestive capacity occurring on the fifth day was normalized again by the beginning of the seventh day. No clear correlation between the number of leucocytes and digestive capacity was noted. (J.F.H.)

16. BRESSON, V., and A. BELLOSSI. 1969.
Etude preliminaire des effets d'un champ magnetique uniforme sur le sang. [Preliminary study of the effects of a uniform magnetic field on the blood.]
Bull. Soc. Med. Afrique Noire Lang. Fr. 14(3):612-614.

Washed red cells, plasma, and serum of citrated or heparinized blood of different blood groups was subjected to the action of a magnetic field varying between 3,000 and 7,000 gauss. The effects obtained have been compared with blood elements subjected to the same manipulations but not exposed to a magnetic field. The action of the magnetic field is manifest on the leucocytes as well as the other blood elements; the hematocrit is somewhat diminished; total blood density is not changed but the plasma density is increased, and plasma viscosity is slightly augmented. Many working hypotheses may be elaborated from these results. (A.R.T.)

17. BUSBY, D.E. 1968.
Magnetic fields.
In: E.M. Roth, ed. Compendium of Human Responses to the Aerospace Environment.
Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mexico. 8 pages. Nov. N69-12434.

The effects of high and low gradient magnetic fields on human performance are presented for space flight applications. Although few human exposures to a magnetically quiet environment have been reported, limited experience has revealed no traceable ailment to such surroundings. It is generally held that the magnitude of the geomagnetic field has remained steady during the long evolution of the Earth, though its polarity and strength have detectably changed. It is assumed that living creatures have become accustomed to the field, and that some biologic processes may be to some degree dependent on it. The known effects of high magnetic fields on man are tabulated. It is stated that caution should be exercised in interpreting these data to mean that the performance of man will not be degraded in high magnetic fields. Recent studies using spider monkeys have indicated that neural and cardiac functions are affected. Although a variety of biological effects have been noted, no definite magnetic dose-effect relationship has been established to date. (A.L.)

18. BUSBY, D.E. 1968.
Space biomagnetics.
Space Life Sciences 1(1):23-63.

The effect of intermittent exposure of human and subhuman organisms to high-intensity, relatively low-gradient magnetic fields during space missions was investigated. From past experience with personnel who enter high-intensity magnetic fields for brief periods of time in their work, it is concluded that exposure to magnetic fields while servicing activated magnetohydrodynamic engines should not be hazardous to astronauts. It is apparent that past exposures of man and subhuman systems to high-intensity magnetic fields do not indicate whether astronauts exposed for up to several days to magnetic field intensities associated with pure magnetic or plasma-radiation shielding could suffer impairment of their health or performance. Further studies will be necessary. (A.L.)

19. BYALOV, A.M., and P.I. SHPIL'BERG. 1969.
Vliyanie magnitnykh plei v usloviyakh proizvodstva na tsentral'nuyu nervnuyu sistemu. (Po dannym elektroentsefalografii).
[Effect of magnetic fields under industrial conditions on the central nervous system. (Electroencephalographic data).]
Gig. Sanit. 34(4):30-35.

Electroencephalographic [eeg] examinations of 192 persons, exposed to the action of magnetic fields in industrial environment, revealed functional changes in the CNS. Persons exposed to the action of low intensity magnetic fields frequently showed a short term desynchronization of the eeg (1st phase of high excitation). Controllers of the production of constant magnets, exposed to the action of high intensity magnetic fields and high temperature, presented eeg with prevalence of synchronized α-waves, and, in rare cases, of θ-wave (2nd and 3rd inhibition phases). (A.L.)

20. CALDWELL, W.E., and F. RUSSO. 1968.
An exploratory study of the effects of an A.C. magnetic field upon the behavior of the Italian honeybee (*Apis mellifica*).
J. Genet. Psychol. 113(2nd):233-252.

The stereotyped nodal behavior, which appeared in the pilot study, reappeared in the exploratory study, proving that the bee was reacting to the magnetic energy field. However, the universality of this response under other magnetic fields, e.g., direct current, and the nature of this response, whether adient, aversive, or reflexive, still remain in question. Further investigation into this behavior is warranted, for its determination suggests a most practical dependent variable for future studies of field effects on nervous activity within biological organisms. (A.L.)

21. CASSIANO, O., Q. CARTA, and S. TRONCONI. 1967.
Azione di campi elettromagnetici eul tasso glicemico in soggetti normali e diabetici. [Action of electromagnetic fields on blood sugar level in normal and diabetic subjects.]
Minerva Anest. 33:326-329.

Twelve normal subjects of both sexes, 18 to 49 years of age, and 12 diabetics, age 16 to 78 years, were examined. The artificial magnetic field strength was about 33.8 gauss. Blood sugar levels were measured before and after exposure to the artificial magnetic field, to a positive electric field, and to a negative electric field, the latter two having a gradient of potential of 10,000 V/m. Results are shown in tables. In normal subjects, blood sugar levels were lower after than before exposure to all three fields, (magnetic field: 70 before, 63.9 after; positive electric field: 79 before, 71.9 after; negative electric field: 72.58 before, 71.41 after). In diabetic subjects, statistical analysis showed values of 184.16 before and 182.83 after exposure to the magnetic field and values of 176.41 before and 185.85 after exposure to a positive electric field. The significance of these findings is discussed. (A.R.T.)

22. CHACHAVA, K.V., L.I. CHARKVIANI, T.G. ZHGENTI, P.YA. KINTRAYA, K.A. NISHNIANIDZE, A.A. LOMINADZE, and I.K. CHACHAVA. 1969. Changes in marrow hemopoiesis due to ionizing radiation and chemical substances used in combating malignant tumors against a background of magnetic field usage.
Soobshch. Akad. Nauk Gruz. SSR 53(2):425-428.

Rats exposed to alternating magnetic fields, 10 min. daily for 10 days, significantly increased the number of leukocytes and erythrocytes in comparison with 30 controls. Of 20 patients between 38 and 73 years, with severe leukopenia due to radiotherapy the same procedure improved the blood picture in 18. The stimulating effect of a magnetic field on hemopoiesis is discussed. (A.L.)

23. CHALAZONITIS, N., R. CHAGNEUX, and A. ARVANITAKI. 1970. Rotation des segments externes des photorecepteurs dans le champ magnetique constant. [Rotation of the external segments of photoreceptors in a steady magnetic field.]
Compt. Rend. Acad. Sci. (Paris), Ser. D. 271:131-133. 6 Jul.

A suspension (Ringer's solution) of external isolated segments of retinal rods from the frog's eye was placed in a small dish over the center of an electromagnet with a constant and uniform magnetic field of 20 kilogauss strength. The apical and mitochondrial (ruptured) ends of the rods face the magnetic poles in either direction in an indifferent manner. When magnetic fields of different strengths were tested, 80 percent of the segments were completely oriented parallel to the axis of the field at 10 kilogauss. An interpretation on the effects observed is discussed. (A.R.T.)

24. CHAO, L., and D.R. WALKER. 1967.
Effects of a magnetic field on the germination of apple, apricot and peach seeds.
Hortscience 2(4):152-153.

The magnetic field reduced the time required for germination and increased the percentage germination of unchilled apple and apricot seeds compared with untreated control seed. The direction in which the radicles were pointing while in the magnetic field influenced the percentage of apple seeds germinating. The magnetic field had no influence on peach seed germination. Abnormal root growth of the apricot seedlings occurred when given the magnetic field treatment. (E.M.D.)

25. CHERNYSHEV, V.B. 1968.
Vozmushcheniya zemnogo magnitnogo polya i biologicheskaya

ritmika zhuka *Trogoderma*. [Perturbations of the earth's magnetic field and the biological rhythm of the beetle *Trogoderma*.]
Zh. Obshch. Biol. 29(6):719-722.

The daily rhythm of the beetle *Trogoderma glabrum* (Coleoptera, Dermestidae) was registered during 284 days under natural light and constant temperature. These beetles were active only during the day, but sometimes their activity underwent noticable changes. These changes were statistically correlated to days when the geomagnetic field was disturbed, thus confirming Brown's hypothesis on the relation of biological rhythms to geophysic factors. The biological rhythm of *Trogoderma* clearly reflects some phenomena connected with variations in activity of the sun. (A.L.)

26. CHERNYSHEV, V.B. 1970.
Psikhologicheskie oshibki pri opredelenii orientatsii hivykh ob'ektov. [Psychological errors in the course of determination of the orientation of living objects.]
Zh. Obshch. Biol. 31(6):742-749.

The orientation of dermestid-beetles, *Dermestes sibiricus* Er., with respect to the geomagnetic field, as well as, *a priori* random orientation of sunflower seeds thrown on a horizontal surface have been determined by different means. The measurement of orientation angles led to spontaneous errors and concentration of results near the main axes of the round scale. When determining the orientation by photographs, an accumulation near the main axes in every 10 and 5° is observed. The orientation of the same objects with the direction of body axis fixed during the experiment in the form of line showed practically random orientation. Hence, the widely accepted method of measurement of the orientation angle is not suitable. (A.L.)

27. CONLEY, C.C., P.V. DROLL, W.J. MILLS, and P.A. CORSAUT. 1967.
Effects of magnetic fields upon biological systems.
In: E.J. Lufer, ed. Space Magnetic Exploration and Technology, Symposium 28-30 Aug. 1967.
Nevada University, Reno, Nevada. p. 339-349.

A space magnetic environment simulation facility was used to observe the effects of both nulled and high magnetic fields on the activities of acid phosphatase, and of two other enzymes, *in vitro*. Results showed the lack of any significant effects by either the high or the low magnetic fields upon all enzyme activities. A biological enzyme assay on mice cells, placed within the nulled area of the activated coils

during the incubation period, markedly reduced cellular enzyme responses to inoculation of a foreign bipolymer, *in vivo*. (G.G.)

28. CONLEY, C.C. 1969.
Effects of near-zero magnetic fields upon biological systems.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields.
Vol. 2.
Plenum Press, New York. p. 29-51.

The influence of near-zero magnetic fields upon biological systems is studied as a basis for evaluating magnetic effects on astronauts outside the terrestrial magnetic field. Techniques used to produce low magnetic fields are considered, and a number of *in vivo* and *in vitro* investigations are discussed. As a result of the studies it is suggested than any biological influence which magnetic fields do exert may be detectable only in cases where a fairly prolonged exposure effects the complex sequences of cellular or biochemical events, rather than where an instantaneous application of a direct magnetic force acts upon a single, specific chemical reaction. (G.R.)

29. CONLEY, C.C. 1970.
A review of the biological effects of very low magnetic fields.
National Aeronautics and Space Administration, NASA-TN-D-5902,
Washington, D.C. 26 pages. Aug.

Studies of the effects upon living organisms exposed to magnetic fields lower than that of the Earth are tabulated according to taxonomic classification. Also included in the tabulation are eleven studies of the effects of fields in the geomagnetic range. Some well controlled experiments appear to have established that certain lower invertebrates, protozoans, and plants are indeed sensitive to the vector of the ambient magnetic field in the geomagnetic range, and that in nearly null magnetic fields the growth, reproductive, aging, behavioral and phagocytic functions of some species are affected. Two studies of very low magnetic field effects are described in detail; these show a reduced cytoenzyme synthesis rate *in vivo* in mice, but no reaction change *in vitro*. (Author)

30. COOK, E.S., J.C. FARDON, and L.G. NUTINI. 1969.
Effects of magnetic fields on cellular respiration.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields.
Vol. 2.
Plenum Press, New York. p. 67-78.

Experiments using intermittent fields measured the respiration of cells or tissues for alternate 10-minute periods with the magnet off (control) and on (experimental) for a total of 2 hours. Field strengths of 80 Oe or higher lowered the respiration of ascites Sarcoma 37 cells by 28.3%. Lower field strengths, up to 10,000 Oe, produced no significant greater effect. The data on embryo mouse kidney and liver cells were similar. The average respiratory depression for mouse embryo kidney (85-5000 Oe) was 29.3%, and for mouse embryo liver (80-10,000 Oe) and young neonatal liver (100 Oe) was 20.6%. The respiration of adult mouse liver (100, 5000 and 10,000 Oe) or the livers of mice 8-9 and 10-11 days of age (100 Oe) were unaffected. Yeast respiration in a field $\leq$ 85 Oe increased by 40.0%. Field strengths of 70, 80, 100 and 1000 Oe produced: no effect; 44.7% depression; 40.1% depression; and, 42.9% depression, in HeLa cell respiration. The effects of a magnetic field on the respiration of responsive tissues appeared to be fully reversible under the conditions studied. The author details the latest design of his respirometer. (L.M.)

31. DANTU, P., A. GUELIN, P. LEPINE, and R.O. PRUDHOMME. 1967. Multiplication des bacteries et des bacteriophages dans un champ magnetique. [Multiplication of bacteria and bacteriophages in a magnetic field.]
Ann. Inst. Pasteur (Paris) 112:649-651. May.

Observations were made in a magnetic field of 45,000 oersteds on 5 microorganisms (*Clostridium perfringens A, Salmonella typhi, Shigella paradysenteriae, Escherichia coli,* and *Staphylococcus aureus*) and 3 bacteriophages (typhoid, and coli-dysenteric types X-174 and C-16). The cultures were assayed after 6 hours of uninterrupted multiplication in the magnetic field. Under the experimental conditions used, the results showed no evidence of an influence of the magnetic field on the multiplication of the bacteria or the bacteriophages that could be detected by the usual methods of titration. A study of *Cl. perfringens, E. coli,* and *Shigella* in a weak field of 300 to 600 oersteds gave equally negative results. The results were based upon a single observation for each of the organisms and bacteriophages. (A.R.T.)

32. DEGEN, I.L., and V.YA. POTASHNIK. 1970.
Izmenenie svertyvaemosti krovi v postoyannom magnitnom pole. [Changes of blood coagulation in a constant magnetic field.]
Vrach. Delo 7:45-46.

Enhancement of human blood coagulation was observed 3.3 times more frequently than reduction with magnetic field tension

of 1500 oersted. No correlation was found between this phenomenon and other factors. Experiments were continued to detect minimum magnitude field tension still able to influence blood coagulation. (C.M.M.)

33. DEGEN, I.L. 1970.
Lecheniye travmaticheskikh otekov magnitnym polem. [Magnetic field therapy of traumatic edema.]
Ortop. Travmatol. Protez. 31:47-49. Nov.

This study reports on the results of treatment of 25 patients suffering from traumatic edema. Study covered 20 women and 5 men, varying in age from under 30 to over 60. Magnetic field therapy was applied only after knitting of broken bones. The magnetic field was applied using a locally made device powered by 220v ac through a rectifier, with a distance between poles of 80 mm and a field intensity of 450 oersteds. Without the rectifier, the device produced a field intensity of 530 oersteds, with 93 mm between poles. An electromagnet with an air gap of 106 mm was also used, creating a variable magnetic field with an intensity of 450 oersteds. In most cases (22) the inflammation began to decrease after one to three daily magnetic field exposure sessions, reaching the greatest decrease between the sixth and tenth days. The remaining edema decreased more slowly with subsequent treatment. The edema of 18 patients disappeared by the end of the course of treatment, that of 6 decreased sharply and only one patient, for whom the course of treatment was interrupted after 11 sessions, showed insignificant decrease in edema. (J.F.H.)

34. DEGEN, I.L. 1970.
Pro mekhanizm vplivu magnitnikh poliv na biologichni sistemi. [Mechanism of the action of magnetic fields on biological systems.]
Akad. Nauk Ukr. RSR, Visn. 34:39-43. Oct.

Description of experiments in which ergograms of muscular work were taken on a Dubois ergometer in a group of 150 healthy male and female persons who were subjected to the action of 450 or 530-oersted magnetic fields. Most of the subjects were unaware of the purpose of the experiments and all of them did not know the time of the magnetic field actuation. Muscular contraction data of the ergograms are treated by variational statistics procedures. It is concluded that the action of a magnetic field on the muscular activity of biological systems is not related to the generation of an emf. (V.Z.)

35. DEGEN, I.L. 1971.
Therapeutic effects of constant and low frequency alternating magnetic fields.
Joint Publications Research Service, JPRS-53091, Washington, D.C. 9 pages. 11 May.
(transl. of Vrach. Delo 3:124-128. 1971)

The biological and therapeutic effects of magnetic fields on the human organism are discussed. Various studies are presented including the relationship of disturbances in terrestrial magnetism and suicides in Zurich and Copenhagen, and diuretic effect of water processed by a magnetic field. It is concluded that existing data are sufficient to support the recommendation to physicians to consider the biological and medical effects of constant and low-frequency variable magnetic fields to expand the range of illnesses for treatment by magnetic fields. (F.O.S.)

36. DELTOUR, G., A. PFISTER, and L. MIRO. 1969.
Realisation et action biologique des ambiances hypomagnetiques. [Realization and biological action of hypomagnetic environments.]
Rev. Med. Aeronaut. Spat. 8(4):175-177.

Review of published information on laboratory methods of geomagnetic field suppression and on biological effects of exposure to low magnetic fields. The reviewed material is essentially of U.S. origin and includes Beischer and Miller's work with human subjects (1962 and 1967), Conley's (1966) and Halpern's (1966 and 1967) work with mice, plants, and microorganisms. (M.V.E.)

37. DERNOV, A.I., P.I. SENKEVICH, and G.A. LEMESH. 1968.
O biologicheskom deistvii magnitnykh polei. [Biological effects of magnetic fields.]
Voenno-Med. Zh. 3:43-48. Mar.

The present investigation established reliable and objective parameters to be used in studies on the effect of magnetic fields on humans. White rats, mice and rabbits were used in the experiments. The animals were exposed to constant magnetic fields for periods lasting from four hours to 10 days, with intensities of 300, 100 and 50 oersteds, and to alternating magnetic fields of 50 c.p.s. frequency and intensities of 50, 100 and 150 oersteds. Results of hematological and morphological studies were presented and discussed. An analysis of the findings showed that the constant magnetic field produced marked biological effects with fields starting at 100 to 150 oersteds. Although large hematological and morphological changes could not be related to structural

changes, the occurrence of a certain shift could be explained by the inhibition of some regulatory function of the central nervous system. The preceding inferences need further experimental corroboration. (F.P.)

38. DOLGOPOL'SKAYA, M.A., I.S. MENDELEEV, and L.V. VLADIMIROV. 1967.
K voprosu o deistvii magnitnogo polya na odnokletochnye infuzorii (Paramecium caudatum St.). [The effects of a magnetic field on a unicellular infusorian (*Paramecium caudatum* St.).]
Biofizika 12(6):1109-1111.

P. caudatum were subjected to a constant magnetic field alternating at a frequency of 50 giga cycles. No gross changes in the movement of the paramecia were noted; however, there was a slight tendency for an alternating movement to prevail over a more progressive directed movement. There were no observed changes in the vitality of paramecia subjected to a 1050 oersted magnetic field for 10-30 min. (D.M.G.)

39. DOROZHKINA, L.I. 1970.
Deistvie postoyannogo magnitnogo polya na energeticheskii obmen infuzorii. [Action of magnetic field on the energy metabolism of ciliates.]
Tsitologiya 12(6):783-786.

Effect of a static magnetic field (intensity of 1000 oersted) was studied on a mass culture of *Paramecium caudatum*. The static magnetic field is shown to decrease the glycogen content, and to increase the amount of lactic acid and the sensitivity to 2,4-dinitrophenol of the infusoria. (A.W.B.)

40. DOSKOCH, Ya.E., V.Yu. STREKOVA, G.A. TARAKANOVA, and B.N. TARUSOV. 1969.
Spontannaya sverkhslabaya khemilyuminestsentsiya rastenii v svyazi s izmeneniem ikh zhiznedeyatel'nosti s postoyannom magnitnom pole. [Spontaneous ultra-weak chemiluminescence of plants in relation to changes in their vital activities in a stationary magnetic field.]
Fiziol. Rast. 16(2):272-278.

Spontaneous ultra-weak chemiluminescence (UWL) emitted by roots of 4-day-old bean plants grown in a stationary magnetic field (SMF) with a field strength of 62, 4000 or 12000 Oe was studied. The SMF affected the intensity of the radiation; weak SMF enhanced the intensity of UWL and strong fields suppressed it. The effect of a SMF of various strengths on the life activity of plants was demonstrated earlier by phy-

siological, biochemical and cytological methods. A comparison of the data obtained by these methods indicated a positive correlation between the intensity of the UWL on the one hand, and the energy efficiency of respiration, mitotic coefficient and growth on the other. The unique relation between chemiluminescence and the energy efficiency of respiration was particularly pronounced in the after-effect 2 days later. On basis of the experimental data it is suggested that a magnetic field disturbs steady state conditions of biological oxidation and the activity of cellular anti-oxidants. Further changes in the nature of lipid oxidation under the action of a SMF apparently involves disturbance of nucleic acid and protein synthesis which ultimately affects cell division and the growth rate. (M.K.)

41. D'SOUZA, L., V.R. RENO, L.G. NUTINI, and E.S. COOK. 1969. Effects of a magnetic field on DNA synthesis by ascites Sarcoma 37 cells.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields. Vol. 2.
Plenum Press, New York. p. 53-59.

Exposure of ascites Sarcoma 37 cells to a 7300 Oe magnetic field for periods of 1-3 hours produces a decrease of DNA synthesis of 18-24% as determined by the tritiated thymidine uptake measured by autoradiography. The depression of respiration by the magnetic field is of the same general magnitude. These phenomena are presumed to be the underlying cause of the tumor growth-inhibitory effect of a magnetic field. (M.M.N.)

42. DUNLOP, D.W., and B.L. SCHMIDT. 1969.
Sensitivity of some plant material to magnetic fields.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields. Vol. 2.
Plenum Press, New York. p. 147-170.

Prolonged exposure to heterogeneous magnetic fields of 500-4500 Oe may produce the following responses in adventitious roots of allium, narcissus and coleus: inhibition of cell reproduction followed by death of embryonic tissue and accompanied by senescence of all root tissue; anomalous development of certain cells and tissues, including nuclear, cytoplasmic, and cell wall abnormalities, with omission of some normal developmental cell types. Pithophora, a less complex organism, showed reduced and markedly abnormal growth of filaments, accompanied by premature and excessive formation of akinetes. The authors concluded that magnetic fields of a strength well in excess of the geomagnetic field generate

an environment unfavorable to growth and normal development, and promote early maturation and senescence of cells, tissues and organisms. (L.M.)

43. EDLINSKIY, I.B. 1969.
Izmeneniya soderzhaniya nekotorykh microelementov v krovi bol'nykh ostrym tromboflebitom nizhnikh konechnostey pod vliyaniyem postoyannogo magnitnogo polya. [Changes in blood content of trace elements in patients with thrombophlebitis of the lower extremities under the influence of a constant magnetic field.]
Vop. Klin. Lech. Zloka. Novoobraz. 34:520-524. Nov-Dec.

The author studied the content of two trace elements, iron and copper, in the blood of patients with acute thrombophlebitis of the lower extremities during the course of treatment with a magnetic field of 200 to 400 Oe. The magnetic lines of force were directed parallel to the neurovascular tracts. The initial duration of each procedure was 15 minutes, increasing by 5 minutes with each subsequent application to a maximum of 30 minutes per day. The duration of the course of treatment was determined by changes in the capillaroscopic picture, oscillographic data, electrothermometry, biochemical analysis of the blood and the clinical picture of the disease; generally, 25-30 treatments were given. No other treatment was used. Patients observed included 39 women and 6 men, mostly between 30 and 60 years of age. Analysis of the results indicated that acute thrombophlebitis is characterized by a decrease in the total content of iron and an increase in the content of copper in the blood. The application of a constant magnetic field improved the general clinical picture, caused an increase in the iron content in the blood and a decrease in the copper content. These changes indicate that the constant electromagnetic field had an effect on the organism as a whole. (J.F.H.)

44. EMLEN, S.T. 1970.
The influence of magnetic information on the orientation of the indigo bunting, *Passerina cyanea*.
Anim. Behav. 18(2):215-224.

In this paper, the possible importance of geomagnetic information for migrating orientation has been examined, using the indigo bunting as the experimental subject. Three series of experiments were conducted: 1) Caged buntings were placed in a planetarium and the artificial sky was manipulated so that magnetic and stellar north did not coincide. In this case the birds oriented with reference to the stellar in-

formation. 2) Birds were tested for directional preferences in a chamber without visual cues and failed to display any directional tendency during or after nightly 8-hour runs for 8 to 13 consecutive nights. 3) An attempt was made to train birds to respond to changes in an artificial magnetic field by means of operant conditioning during the spring and again in the fall. No evidence was obtained to indicate that the indigo buntings could perceive and respond to directional changes in weak, static magnetic fields. (A.R.T.)

45. FARKAS, F., N. RACOVEANU, and G. GEORGESCU. 1970.
Modificari morfologice ale nucleului lumfocitelor la persoane expuse actiunii cimpurilor electromagneticue. [Morphologic alterations in the lymphocyte nucleus of persons exposed to the action of electromagnetic fields.]
Igiena 19(5):305-310.

Two groups of persons exposed to magnetic fields were studied: the 1st group (4 subjects) received a treatment with pulsating magnetic field and the 2nd (10 subjects) was exposed to a more powerful continuous magnetic field (6-10 x 10^7 Oe). The incidence of binucleate, bilobate and lobate lymphocytes was slightly higher in the 2nd group. The subjects exposed to magnetodiaflux and ^{132}I, previously studied, exhibited a significant increase in lymphocytes with nuclear alterations. The role of the magnetic field in the appearance of lymphocytes with nuclear alterations is not clear. (M.F.)

46. FEDOROV, B.M., and V.S. NEVSTRUYEVA. 1971.
Changes in the sympathecoadrenal system caused by exposure in a permanent magnetic field.
Space Biol. Med., USSR 5(2):53-59.
(transl. of Kosmicheskaya Biologiya i Meditsina 5(2):38-42. 1971)

The effect of a permanent magnetic field on the sympathicoadrenal system in rabbits was investigated. The experiments produced a stimulating effect on the sympathetic nervous system. Twenty-four hour exposure to hypokinetic conditions considerably reduced the noradrenaline content in the hypothalamus and myocardium, but exerted no effect on the adrenaline content in the medullary layers of the suprarenals. Twenty-four hour exposure to a permanent magnetic field of 1,000 Oe prevented any decrease in the noradrenaline content in the hypothalamus and myocardium of hypokinetic rabbits. (Author)

47. FRIEDMAN, H., R.O. BECKER, and C.H. BACHMAN. 1967.
Effect of magnetic fields on reaction time performance.
Nature (London) 213(5079):949-950.

Seated human subjects were positioned so that the cerebrum was approximately at the center of transverse magnetic fields. In a darkened room, each subject was instructed to press and promptly release a telegraph key mounted on a lapboard after the appearance of an eye-level red light 7 feet away. In one experiment, steady state fields of 5 and 17 gauss were used with 18 male schizophrenic subjects, 22 to 49 years of age. No statistically significant effects on reaction time performance was noted. In a second experiment, 30 clinically normal male subjects, aged 19 to 32 years, were placed in 3 groups of 10 each: control; subjected to a sinusoidally modulated field of 5 to 11 oersteds at 0.1 cps; or exposed to a similarly modulated field, but at 0.2 cps. The data indicated that the effects of the 0.2 cps condition were significantly different ($P < 0.05$) from those in the 0.1 cps. In a third experiment, 30 female subjects, 17 to 40 years of age, were used in a design similar to the second experiment. The same statistical significance between the groups was found. In general, the findings indicated that experimentally produced modulated magnetic fields can significantly increase reaction time performance. (A.R.T.)

48. FRIEDMAN, H., and R.J. CAREY. 1969.
The effects of magnetic fields upon rabbit brains.
Physiol. Behav. 4(4):539-541.

Rabbits were exposed to steady state and sinusoidally modulated magnetic fields of several levels of flux density for varying periods of time up to 60 hr. In those cases in which neuropathology was found, the results were consistent with the presence of the endemic encephalitozoonosis common to American rabbit colonies. This is in contrast to the findings of other investigators who attributed the histopathology directly to the effects of the imposed magnetic fields.

49. GAGOSHIDZE, N.Sh., D.F. GUGUSHVILI, T.G. ZHGENTI, K.N. KHOMASURIDZE, and S.N. TSAGARELI. 1969.
Vliyaniye peremennogo magnitnogo polya nizkoy chastatoty na vyrabotku elektrooboronitel'nykh uslovnykh refleksov u belykh krys.
[Influence of variable low frequency magnetic field on development of electric defense conditioned reflexes by white rats.]
Zh. Vyssh. Nerv. Deyatel'nosti 19(1):172-173.

Studies were performed on sexually mature white rats weighing 250 to 300 g. The conditioning stimulus was the light of an electric lamp; the unconditioned stimulus was 30 v electric shock applied through the floor of the chamber in which the rats were kept. The conditioning signal was given for 15 seconds, followed by 5 seconds signal plus shock. The current was turned off if the rats jumped up onto a shelf lo-

cated at a height of 7 cm over the floor. Ten tests were performed each day. A magnetic field of 3.75 Oe and 6.8 Hz was applied to the ten rats in the experimental group each day immediately before the conditioned reflex experiment. 9 other rats were not subjected to the influence of the magnetic field and served as a control. The experiments showed that the variable magnetic field accelerates the development of the avoidance reflex. The animals in the experimental group developed the defense reaction with a probability of 0.9 after 8 days, while the control animals required 11 days to reach this level of probability. (J.F.H.)

50. GAK, E.Z. 1967.
Biological effect of a constant magnetic field.
In: J. Cinovskis, ed. Morfol. Khim. Izmen. Protsesse Razv. Kletki, Dokl. Konf., Riga 1965.
Izd. Zinatne, Riga, USSR. p. 125-132.

The rate of chemical reactions does not change in magnetic fields of up to 10^4 Oe; thus effects have low probability from the point of view of thermodynamics. In spite of this fact, the spatial distribution of metabolites and enzymes and mobility of blood elements may be changed without a change in energetic balance. In a closed model system in which the intensity of both magnetic and electrical fields were homogeneous and perpendicular to each other, the movement of a strong electrolyte (H_2SO_4) in the direction of acting force was observed. In the non homogeneous system (both magnetic and electrical fields are non homogeneous) the circulation of electrolytes was observed. The velocity of electrolyte movement and its form were dependent on the intensity of fields, viscosity, and geometric parameters of the system. The effect may be explained by the fact that the energy of moving particles is constant in a constant magnetic field, but the particle impulses are changed. The influence of a constant magnetic field upon the blood and lymph circulation, and the possibility of movement within the cell are discussed. (J.K.)

51. GALIANI, H.L. 1969.
Ionizing radiation and magnetic fields: A review of their effects on the nervous system.
Massachusetts Institute of Technology, Man-Vehicle Lab., Cambridge, Mass. NASA-CR-107358. 30 pages. Feb.

Data on the functional sensitivity of the nervous system to ionizing radiation and magnetic fields suggest caution in prolonged human exposure to such environments. Unfortunately, these conditions are characteristic of those expected during a space flight. Studies are thus needed to determine the

nature and mechanism(s) of the nervous system's reactions to these and other factors, and to investigate the degree to which the astronaut's performance capabilities may be affected. Such knowledge would also prove helpful in determining protection standards for occupationally exposed personnel and in medical research. (Author)

52. GEACINTOV, N.E., F. VAN NOSTRAND, M. POPE, and J.B. TINKEL. 1971.
Magnetic field effect on the chlorophyll fluorescence in Chlorella.
Biochim. Biophys. Acta 226(2):486-491.

The weak fluorescence of chlorophyll-a in the green algae *Chlorella pyrenoidosa* has been found to be sensitive to an external magnetic field. The red fluorescence of an *in vivo* suspension of *Chlorella* cells may be either increased or decreased depending on the direction of the exciting light beam with respect to the magnetic field. Experiments were carried out in a coil solenoid magnet on 3 to 6-day-old cultures. The magnetic field was homogeneous; field strengths from zero to 145 kgauss were studied. The light source was a 100-watt mercury lamp and the light was filtered with a band pass of 340 to 620 nanometers. When the direction of the light beam was parallel to the magnetic field of about 16 kgauss or more, the chlorophyll-a fluorescence in *Chlorella pyrenoidosa* could be enhanced by 4 to 9 percent, and could be decreased by a similar amount if the light beam was oriented perpendicular to the magnetic field. The changes in fluorescence induced by magnetic fields may be due to a reorientation of the pigment molecules which may give rise to changes in energy transfer efficiencies. Such orientation phenomena can be explained in terms of cooperative effects between molecules with anisotropic magnetic susceptibilities, which are known to align small muscle fibers and molecules in liquid crystals. (A.R.T.)

53. GIBSON, R.J., I.R. ISQUITH, and R.M. GOODMAN. 1967.
Blepharisma growth in "null" magnetic field.
Franklin Institute, Research Labs, Philadelphia, Penn. NASA-CR-91399. 104 pages. 31 Jul.

A slow-moving heterotrichous ciliate, *Blepharisma intermedium*, was studied to determine the effects of a magnetic field on cells. Since the culture included bacteria necessary as a food supply for the *Blepharisma*, observed effects of the magnetic field must take into account the role played by the bacteria. Even though the magnetic diminution may have affected the growth of the *Blepharisma*, no drastic cytological changes were observed. The only possible cytological differ-

ence was that the cells grown under ambient conditions seemed slightly longer than those from the null field. If this is actually the case, it may be an indication that null field cells are dividing faster and, therefore, producing slightly smaller cells than the controls. Clonal frequencies and averages are discussed, and data from 30 clonal experiments are summarized. (M.W.R.)

54. GIBSON, R.J. 1969.
A monograph on magnetic fields for life scientists. Vol. 2. Franklin Institute, Research Labs., Philadelphia, Penna. NASA-CR-107483. 154 pages.

This report is a general compilation of materials related to magnetobiology. Topics discussed include the dimensions and unit systems of the magnetic quantities, fundamentals of magnetic fields, the design of air core coils and permanent magnet assemblies for producing magnetic fields, the Earth as a permanent magnet, the design of shields to reduce magnetic fields, and the measurement of magnetic fields and instrumentation required. (R.B.)

55. GLASER, R. 1968.
Elektromagnetische felder und belebte natur. [Electromagnetic fields and organic nature.]
Naturwiss. Rundsch. 21(10):434-435.

The relationship of electromagnetic fields to living organisms is reviewed with respect to 3 areas: the action of external fields upon biological systems; fields as information carriers for the control of life processes within an organism; and electromagnetic radiation as a means of communication between organisms. (W.G.H.)

56. GOTTLIEB, N.D., and W.E. CALDWELL. 1967.
Magnetic field effects on the compass mechanism of the snail *Helisoma duryi endiscus*.
J. Genet. Psychol. 111:85-102. Sep.

This investigation was undertaken: to test the theory that a very weak magnetic field is a significant part of an organism's environment; to attempt to achieve results concerning orientation effects elicited by magnetic fields of different strengths and orientation; and, to present evidence of the importance of time of day and month as significantly differential environmental factors. Ten common aquarium snails served as subjects throughout the experiment. They were run in approximately 115 trials in an apparatus devised for the

"whole-compass" technique under each of the 4 field conditions: Earth field (control), augmented field (oriented North), reversed field (oriented South), and East-West field. Three times daily, between 8 and 10 A.M., 11 A.M. and 1 P.M., and between 4 and 6 P.M., for 3 weeks the snails were individually run in a 1.5 oersted artificial magnetic field of the 3 orientations. Directional behavior and activity level were considered to be indicants of experimental effects. A definite difference was found between the activity levels produced under the conditions of the augmented and reversed fields, and under those of the augmented and East-West fields; a definite trend towards a difference between the Earth's field and reversed field conditions was also found. The activity level of the 11 A.M. to 1 P.M. distribution was statistically significantly different from the other time distributions. Statistically significant differences in directional behavior were found between the 9 to 10 A.M. and 11 A.M. to 1 P.M. distributions and between the 11 A.M. to 1 P.M. and 4 to 6 P.M. distributions, but, not between the 8 to 10 A.M. and 4 to 6 P.M. distributions. (A.R.T.)

57. HABERDITZL, W. 1967.
Enzyme activity in high magnetic fields.
Nature (London) 213(5071):72-73.

To study the magnetocatalytic effect of L-glutamic dehydrogenase (GDH) the following reaction catalyzed by GDH was used: 2-oxoglutarate + ammonia + reduced nicotinamide-adenosine dinucleotide > glutamate + nicotinamide-adenine dinucleotide + water. Temperatures ranged between 20-25°C. In the case of catalase the influence of magnetic field on activity was determined by the catalytic decomposition of hydrogen peroxide. The experiments were carried out both in a uniform magnetic field (variation of 3% over the sample length of 4 cm.) and in a non-uniform field (variation of 30% over 4 cm.). From the tabulated results it appears that for GDH in a uniform field decrease in activity between 5% and 12%, in a non-uniform field it reached very high values. Appreciable increases in catalase activity in the magnetic field were observed, especially for non-uniform fields. (P.G.)

58. HANNEMAN, G.D. 1967.
Changes produced in urinary sodium, potassium, and calcium excretion in mice exposed to homogeneous electromagnetic stress.
Aerosp. Med. 38(3):275-277.

Female mice were exposed to a homogeneous magnetic field of 14,000 Oe. for 24 hours. Twenty-four-hour urine samples obtained before, during, and after exposure were analyzed for Na^+, K^+, and Ca^{2+} concentrations by flame spectrophotometry.

The mean concentration of the ions after exposure increased from that before exposure: Na^+ from 2.34 to 4.29; K^+ from 9.14 to 14.59; and, Ca^{2+} from 0.083 to 0.138 mg./cc. The changes for Na^+ and K^+ were statistically significant. (L.N.E.)

59. HANNEMAN, G.D. 1969.
Changes in sodium and potassium content of urine from mice subjected to intense magnetic fields.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 127-135.

Exposure of female mice to a magnetic field increased the urinary excretion of Na and K; the magnitude of this effect depended on the intensity of the magnetic field and the duration of the exposure. The change in urinary cation output is thought to reflect a change in the gradient of electrical potential or concentration gradient across the cell membrane. (M.M.N.)

60. HEFCO, V., C. BIRCA, and M. HABA. 1969.
Metabolic modifications in rats under the influence of magnetic fields (m.f.) with different characteristics.
Rev. Roum. Biol. Ser. Zool. 14(3):227-236.

The modifications of lactic acid, pyruvic acid and glycemia are presented under the influence of magnetic fields of different intensities, of different magnetic doses, of different modes of orientation of the mf lines of force, and of various intervals between treatments. The conclusion reached is that non-uniform mf produce greater biological effects than uniform ones. Magnetic fields generated by an alternating and pulsatory current produce greater biological effects than continuous ones. Within certain mf intensity limits, the organism responds in a constant manner. (K.M.E.)

61. HONG, F.T., D. MAUZERALL, and A. MAURO. 1971.
Magnetic anisotropy and the orientation of retinal rods in a homogeneous magnetic field.
Proc. Nat. Acad. Sci. U.S. 68(6):1283-1285.

The reported orientation of retinal rods in a homogeneous magnetic field can be explained by the magnetic anisotropy of oriented molecules in the disc membranes of the rods. The energy of a single rod as a function of orientation in the magnetic field, the time required for alignment of the rod in a viscous medium, and the fluctuations of orientation are cal-

culated. Arguments that rhodopsin is the constituent responsible for the effect are given. The possibility of orientation due to inhomogeneity of the magnetic field is ruled out. The application of magnetic anisotropy as an experimental tool in biology is indicated. (L.P.)

62. IVANOV-MUROMSKIY, K.A., and A.I. LUKHACHEV. 1967.
Vliyaniye postoyannogo magnitnogo polya na krov' i tsentral'nuyu nervnuyu sistemu cheloveka i zhivotnykh. [Influence of constant magnetic field on blood and central nervous system of man and animals.]
In: Certain Problems in Biocybernetics, The Use of Electronics in Biology and in Medicine (Collection of Articles). Foreign Technology Div., Wright-Patterson AFB, Ohio. FTD-MT-24-291-67. p. 69-75. AD-678472.
(transl. of Seminar Nekotorye Problemy Biokibernetiki, Primenenie Elektroniki v Biologii i Meditsine, Kiev, no. 1, 1967.)

During the application of a permanent magnetic field, (field strength 7000 G) to the central nervous system of rabbits, there were noticable changes in the blood picture, a decrease in the rate of erythrocyte sedimentation and hemoglobin content and a sharp increase in the number of leucocytes; in the character of the electroencephalogram, appearance of slow oscillation "spindles"; and, in the histological structures of the brain, perivascular edema and sometimes a loss of myelin fibers. The only observed influence of a permanent magnetic field on the brain of man was an increase of the threshold of sensitivity to electrical stimulus and fatique-strength to pain. The magnetic field did not affect the body temperature of either man or animals. (L.A.)

63. JITARIU, P., J. MATHILDE, and M. ISAC. 1967.
Effect of uninterrupted pulsating electromagnetic fields on plasma protein fractions and the coagulation process in the rabbit.
Rev. Roum. Biol., Ser. Zool. 12(2):91-95.

An uninterrupted pulsating magnetic field was applied each day for three minutes with north oriented toward the head. The total protein level was reduced 4.38 g. in 5 days, with the greatest decrease in albumins and γ-globulin. The Howel test for coagulation showed an increase after 5 days. The Quick time, preaccelerin time, and proconvertin time were increased after 10 days. Modifications appeared in the reactivity of the proteins, as measured by changes in fixed sugar. Blockage of the reticuloendothelial system by Largactil caused a decrease in total proteins, mostly of albumins. After a magnetic field was applied to these animals the general picture of total proteins was not changed, but the globulin fractions oscillated. (V.Z.)

64. JITARIU, P., and I. MIHAIL. 1968.
Effect of a pulsing magnetic field on the oxidative phosphorylation of an albino rat brain affected with audiogenic convulsion.
An. Stiint. Univ. "Al. I Cuza" Iasi, Sect. 2a, 14(1):1-6.

Rats susceptible to audiogenic stimulation were exposed to a pulsing magnetic field (PMF) of low intensity and low frequency for 5-10 days at 15 min. a day. Exposure to a PMF resulted in changes in the seizure patterns, and in P and O contents of the brain as well as in the P/O ratios. Seizures were markedly less violent and both clonic and clonic-tonic phases decreased in favor of the resting period. The P/O ratio was significantly increased after 5 exposures to a PMF. After 10 days of treatment the P/O ratio, however, decreased (not significantly). Oxidative phosphorylation processes in the mitochondria from the brains of rats are discussed. (V.N.N.)

65. JITARIU, P., V. HEFCO, E. HEFCO, C. BIRCA, and R. BRANDSCH. 1968.
Effect of magnetic fields on carbohydrate metabolism. II. Effect of magnetic fields on sugar level, lactic and pyruvic acids in guinea pig blood.
An. Stiint. Univ. "Al. I Cuza" Iasi, Sect. 2a, 14(1):7-13.

Guinea pigs were exposed to magnetic fields (MF) of 3 sec. on, 1 sec. off, for 5 min./24 hrs. for 5-15 days. Lactic acid (I), pyruvic acid (II) and blood glucose (III) levels changed following exposure to MF depending on the length of treatment. Max. I and II values were found after 5 days; max. III values were found after 10 days. The biological effects of MF on metabolic and neurosecretory regulatory systems are discussed. (V.N.N.)

66. KATOLA, V.M., and A.N. KOVALEVSKAYA. 1970.
Dinamika eksperimental'noi breslavl'skoi infektsii u belykh myshei pod vliyaniem postoyannogo magnitnogo polya. [Dynamics of experimental infection with *Salmonella breslau* in white mice exposed to the effect of permanent magnetic field.]
Zh. Mikrobiol. Epidemiol. Immunobiol. 47(10):142-143.

Two experimental groups of white mice were kept in a constant magnetic field with the reluctance on the magnetic poles of 2500 oersted. One group was infected with *S. breslau* shortly before it was placed in the magnetic field; the other group was infected after 10 days of exposure to the magnetic field. A control group was infected simultaneously and kept under normal conditions. Clinical signs of disease occurred in the experimental groups 2 days later and the intensity of multiplication

of bacteria was lower due to the blockage of bacteria in mesenteric lymph nodes following peroral infection. (O.B.)

67. KATOLA, V.M. 1970.
Vliyanie postoyannogo magnitnogo polya na chuvstvitel'nost' k antibiotikam bakterial'noi populyatsii. [The effect of a permanent magnetic field on the sensitivity of bacterial populations to antibiotics.]
Antiobiotiki 15(5):421-422.

Bouillon cultures of strains of white nonpathogenic *Staphylococcus*, yellow *Sarcina*, *Staphylococcus aureus* 209 P, *Escherichia coli* AB247 and P678 and *Salmonella breslau* strain Lt_2 were put in a constant magnetic field at an intensity of 2500 oersteds for up to 30 days. In addition the sensitivity for penicillin, streptomycin, levomycetin [chloramphenicol], tetracycline, erythromycin and neomycin of *E. coli* taken from white mice and rats and *S. breslau* and golden *Staphylococcus* taken from the organs of dead mice was studied after exposure to a magnetic field of 1400-2500 oersteds. The sensitivity of white *Staphylococcus* to antibiotics did not change with uninterrupted cultivation for 30 days. With 12 passages in the magnetic field there was a significant increase in sensitivity to erythromycin. A correlation between the presence of "warty" growth and sensitivity to antibiotics was found in 246 substrains of yellow *Sarcina*. In the magnetic field *Sarcina* had heightened sensitivity in the summer, but in winter its resistance increased compared to the control. Resistance to streptomycin and levomycetin appeared in *E. coli* from "magnetized" animals starting on the 15-16th day in the magnetic field. A greater length of time did not increase resistance. *E. coli* bouillon culture in the magnetic field did not differ from the control in sensitivity. Analogous results were observed with *S. breslau* and golden *Staphylococcus*. (N.L.G.)

68. KEETON, W.T. 1971.
Magnets interfere with pigeon homing.
Proc. Nat. Acad. Sci. 68(1):102-106.

The effect of magnets on the homing behavior of pigeons was reinvestigated. Each of the tests described in this paper consisted of releasing alternatively, individual pigeons from 2 groups; the experimental birds had a 2.7 g. magnet glued, just before release, to the back at the base of the neck, and the control birds wore a brass bar of similar size and approximately the same weight, 3.2 g. The strength of the magnets was about 255 gauss (oersteds) at the poles; the field strength at the bird's head was roughly 0.45 gauss. Tests seemed to indicate that magnets do not usually disorient experienced birds when the

sun is visible (at least at short distances), but that they usually do cause disorientation at unfamiliar release sites when the sun is not visible. In tests with experienced young birds, disorientation was often caused by the magnets when the test flights were made in sunlight and there was also some indication of disorientation in experienced pigeons when the sun was visible but the distance was longer. It is concluded that if further research proves that magnetic cues are used by orienting birds, it seems clear that such cues, and the solar cues that are already known to be used, will not provide a full explanation of the birds' orientation system. (A.R.T.)

69. KHOLODOV, J.A., M.M. ALEXANDROVSKAYA, S.N. LUK'YANOVA, and N.S. UDAROVA. 1969.
Investigations of the reactions of mammalian brain to static magnetic fields.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 215-225.

Conditioned reflex, electrophysiological, and histological methods were used to investigate the initial reactions of the rabbit brain to static magnetic fields (SMF). The electrodefensive conditioned reflex was produced in response to a 1000-Oe SMF, although slowly. The properties of this reflex were weaker than those of the acoustic conditioned reflex. The electroencephalogram (EEG) tracings showed an increase in the number of spindles and of slow waves, patterns which are indicative in appearance of a certain phase of sleep in the mammalian brain. Analyses of data by several methods confirm that the SMF increases the amplitude and often decreases the frequency of the biopotentials of the mammalian brain. Local responses from various regions of the brain and the response of individual neurons were studied and are discussed. The effect of the SMF on neuronal activity stimulated by light and by sound is discussed. The main peculiarity of the reaction of the mammalian brain to an SMF is the predominance of the inhibitory process, and the second is its latent period. The third peculiarity is the long-term effect which was noted in the reaction of the glia to the SMF. (A.R.T.)

70. KHVEDELIDZE, M.A., M. Sh. LOMSADZE, N.B. SHARASHIDZE, and M.N. CHKALESHVILI. 1968.
Magnetic effect during photosynthesis.
Soobshch. Akad. Nauk Gruz., SSR 51(3):693-696.

Pretreatment of wheat Upkho-1 seeds in a magnetic field of 2000 Oe. by the orientation of the germinal part of the seed to the south pole for 30 minutes caused a more intensive growth of the

plant and a greater absorption of CO_2 by the leaves. Seed orientation perpendicular to the magnetic field has a smaller effect. (K.K.)

71. KHVEDELIDZE, M.A., S.I. DUMBADZE, M. Sh. LOMSADZE, and N.A. DATEVASHVILI. 1968.
Issledovanie orientatsii semyan rastenii v postoyannom magnitnom pole do nachala ikh prorastaniya. [A study of the orientation of plant seeds in a constant magnetic field before the beginning of sprouting.]
Elektron. Obrab. Mater. 1:58-66.

Dry wheat seeds suspended on fine silk threads were oriented along the lines of force in a magnetic field of 250-1000 oersteds. The embryo side of the grain usually deviated toward the north pole. After dry wheat and barley seeds had been exposed for 30 minutes in a 200-oersted magnetic field, they showed a higher germination rate (8 of 9 seeds geminated, as contrasted with 6 control seeds of 9); there was also heightened resistance to stress in liquid N and boiling water. Seeds which had been placed in a magnetic field were found to contain growth stimulators (IAA) and inhibitors and, in addition, larger amounts of ash elements, especially Fe (twice as much as in controls) and Mn (10 times as much). (K.B.)

72. KOGAN, A.B., L.I. DOROZHKINA, and E.M. VOLYNSKAYA. 1968.
Vliyanie postoyannogo magnitnogo polya na fagotsitarnuyu aktivnost' parametsii. [Effect of static magnetic field on the phagocytic activity of paramecia.]
Tsitologiya 10(10):1342-1348.

Paramecium caudatum were exposed to the action of a magnetic field (tension from 75 to 3000 oersted). The phagocytic activity of the ciliates becomes higher as the tension of the magnetic field was found with the tension of 1000 oersted. The sensitivity of the ciliates to the magnetic field changes significantly with the growth of the culture. The largest sensitivity was found in 1-day cultures during the phase of exponential growth, when the threshold of the action of magnetic field was 100 oersted. With the aging of the mass culture, the threshold increased to 125 oersted. (D.M.G.)

73. KOLIN, A. 1968.
Magnetic fields in biology.
Physics Today 21(11):39-50.

Constant magnetic fields have been shown to affect plant growth and animal development; alternating magnetic fields have been

used to stimulate nerves and to evoke visual sensations; and, activity of nerves and muscles has been known to be accompanied by transient magnetic fields. Magnetotropism in plants is discussed and illustrated. The effects on *Drosophila melanogaster* development and inheritable characteristics of homogeneous and nonhomogeneous magnetic fields are discussed. Magnetic field fluctuations in the human retina, heart, brain, and nerves; blood flow determination by electromagnetic flow transducers; electromagnetophoresis, and electromagnetokinetic effects are discussed. The review is concluded with a brief reference to the most sophisticated use of magnetic fields in biological research - the biological applications of nuclear magnetic resonance and electron spin resonance. (A.R.T.)

74. KOLIN, A. 1970.
Electromagnetic separation of biological particles.
California Univ., Los Angeles, California, final technical report, 1 May 1960-31 August 1969. N70-42225. 11 pages. 13 Aug.

The project began with the general objective of utilizing electromagnetic forces in biological research methods. The phenomenon of electromagnetophoresis was discovered and explored. The possibility of stimulating irritable tissues without electrodes by alternating magnetic fields was demonstrated. The method of electromagnetic determination of blood flow was further developed and has become a standard method in biological and medical research, and in operating room blood flow measurements on human patients. The main investigations led to the conception of the method of isoelectric focusing which is now widely used in biochemical research for protein analysis. Combination of electric and magnetic fields in a new configuration led to the development of the rotationally stabilized method of endless fluid belt electrophoresis which has high resolving power and is applicable to macromolecules as well as biological particles. This method is now being refined to use in measurements of electrokinetic properties of microorganisms. (Author)

75. KORDYUKOV, E.V. 1969.
Magnitoterapiya bol'nykh obliteriruyshchimi zabolevaniyami perifericheskikh sosudov. [Magnetotherapy of patients suffering from obliterating diseases of the peripheral vessels.]
Vop. Kurortol. Fizioterap. 34:227-229. May-June.

The authors have developed an apparatus (not described) which creates an even magnetic field over the entire length of an extremity or individual segments of the extremity without heating and vibration, with the magnetic lines of force directed along the neurovascular tracts. 87 patients suffering from atherosclerotic damage to the peripheral arteries and 92 patients

with endarteritis were subjected to a course of treatment involving daily application of the magnetic field for from 5 to 15 minutes for 30 days. The treatment resulted in a general improvement of the hemodynamics of the lower extremities, manifested as a tendency toward normalization of oscillographic indicators and skin temperature, a decrease in pain and chill sensations, increased ability to walk without pain and improved general condition of the patients with obliterative diseases of the vessels of the lower extremities. (J.F.H.)

76. KUGOT, A.S., V.I. ORESHKO, and E.F. BOCHAROV. 1969.
Izuchenie deistviya postoyannogo magnitnogo polya na fermentativnuyu aktivnost' kishechnoi palochki. [Studies on the effects of a constant magnetic field on the enzymatic activity of the colon *Bacillus*.]
Izv. Sib. Otd. Akad. Nauk SSSR Ser. Biol. Nauk 3:137-138.

Cultures of *Escherichia coli*, strain B, were subjected to a constant magnetic field of 150 oersteds during cultivation. The cultures were incubated at 37°C and transferred every day. The cultures lost the ability to produce indole after 2 days exposure to the magnetic field and the ability to form H_2S after 8 days. The ability of the organisms to degrade carbohydrates was decreasing during this time. The strain could utilize sucrose with the formation of acid; lactose, mannitol and glucose were fermented to acid and gas prior to the exposure. The ability to form gas from lactose was lost after 2 days of exposure, glucose was not fermented after 8 days and none of the sugars could be degraded after 12 days. (R.W.)

77. LEBEDEV, V. 1968.
Scientist reviews problems of space psychology.
In: Problems of Space Research Investigated.
Joint Publications Research Service, JPRS-46446, New York.
p. 1-12. 18 Sep.
(transl. of Nauk i Zhizn 3:25-29, 110-111. 1968.)

Psychophysiological factors affecting interplanetary spacecrews are reviewed. The electromagnetic field influence on mental processes is examined, and it is hypothesized that a system of bioelectrical potentials, located on body surfaces, interacts with the Earth's magnetic field. A general physiological mechanism of a conditioned time reflex (biological clock) is considered in terms of the effect of the pulsating geomagnetic field. An understanding of these phenomena is necessary to explain the effects of the absence or variations of terrestrial magnetism on the processes of cosmonauts. An evaluation of the periodical rhythm of plant and animal life activities and its interruption led to the conclusion that a sound rhythm activity

must be established for crew members to maintain high operational capabilities and to raise the reliability of the man-automaton system. (B.P.)

78. LEISLE, V.F., and A.V. NIKULIN. 1967.
Vliyanie magnitnogo polya nizkoi napryazhennosti na rostovye protsessy kukuruzy, podsolnechnika i sakharnoi svekly. [The effect of a low-tension magnetic field on the growth processes of corn, sunflower, and sugar beets.]
Zap. Voronezh. Sel'skokhoz. Inst. 34:113-115.

Dry corn and sunflower seeds, oriented with their radicle toward the south magnetic pole of the Earth or of a magnet, sprouted 1-2 days earlier than did controls, but seeds oriented toward the north did not differ from controls. The stimulation of the sprouting of the seeds caused an intensified growth rate of the seedlings. The action of an artificial magnetic field of higher power (20 ergs) than that of the Earth (0.5 ergs) caused a stronger reaction. There was a 35% increase in the respiration rate of sugar beet leaves in the magnetic field of a Helmholtz ring. (K.B.)

79. LEVENGOOD, W.C. 1967.
Morphogenesis as influenced by locally administered magnetic fields.
Biophys. J. 7(3):297-307.

An alteration in morphogenetic development induced in *Drosophila melanogaster* pupae by exposure to a magnetic probe was shown to persist for more than 30 generations. With succeeding inbred crossings, an initial increase in the time of development through the embryonic and postembryonic stages gradually approached the level found in control cultures. As the development time decreased, a concomitant increase occurred in the yield of progeny. The pattern of morphogenesis suggested a condition of homeostasis operating in an oscillating epigenetic system. The concept of a feedback control mechanism was employed to examine details of the alterations in development time. The data was compatible with this mode, and rates of recovery from an initial perturbation were determined in several series inbred for a large number of generations. Variations in rate constants and mechanisms involved in the magnetic field inhibition are discussed. (Author)

80. LIBOFF, R.L. 1969.
Biomagnetic hypotheses.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 171-176.

Two rules of thumb are stated for standard magnetoactive diffusion which appear to rule out the possibility that a magnetic field can influence the state of a cellular system through a mechanism interfering with the ionic diffusion process: 1) magnetic fields interact with charges in motion; and, 2) the orbit of a charged particle in the presence of a steady magnetic field is helical. These facts are discussed in relation to the assumption that the growth process of cells is related to the diffusion mechanism of dissociated salts across the plasma membrane and the nuclear membrane. In view of the severe criteria developed, it might be supposed that only the most gigantic of magnetic fields could influence the growth dynamics of a cell, via the mechanism of interfering with the ionic diffusion process. However, one must consider the effects of a potential difference which is known to exist across the cell membrane of many cells. Formulae and equations are developed and discussed with relation to the diffusion of ions across the membrane when a superimposed steady magnetic field is turned on and when turned off. Experimental evidence seems to indicate that, when placed in a uniform magnetic field, the roots of certain plants tend to reorient themselves with respect to the magnetic field. This effect is discussed in terms of magnetic moment, torque, and strength of surface current. (A.R.T.)

81. LIKHACHEV, A.I. 1968.
Vliyanie polya postoyannogo elektromagnita na dinamiku krovotoka teplokrovnykh. [Effect of constant electromagnetic fields on blood flow dynamics in warm-blooded animals.]
Elektron. Obrab. Mater. 1:75-80.

A constant magnetic field has an inhibiting effect on the blood flow process in warm-blooded animals. Since tissue, intracellular fluid and integument have a permeability of unit order, this cannot explain the effect on the blood flow dynamics under strong fields. A cohesiveness in the blood was noted during different currents of blood flow. (R.Z.B.)

82. LIKHACHEV, A.I. 1969.
Changes in the erythrocyte sedimentation rate of rabbits due to exposure of the central nervous system to a constant magnetic field.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York, p. 137-145.

The effect of a constant magnetic field on the blood picture of rabbits was investigated. The exposure of the rabbits to a 5000 Oe field in the presence of an intensive inflammatory process (when the erythrocyte sedimentation rate becomes

greatly increased) led to a very rapid normalization of the ESR. The leukocyte count rose much more rapidly in rabbits exposed to the magnetic field, seeming to follow the extent to which the inflammatory process subsided more rapidly. The blood hemoglobin concentration appeared to fall in the magnet-group rabbits; however, this tendency must be examined further before conclusions may be drawn. The action of the magnetic field exerted control on the circulatory system through the centers of the central nervous system, especially the medulla and the diencephalon. The author suggests that the study of blood changes produced by magnetic fields could prove useful as a diagnostic tool in diseases of the circulatory system and other related systems. (L.M.)

83. LINDAUER, M., and H. MARTIN. 1968.
Die schwereorientierung der bienen unter dem einfluss des Erdmagnetfeldes. [The Earth's magnetic field affects the orientation of honeybees in the gravity field.]
Z. Vergl. Physiol. 60(3):219-243.

The direction in the waggle dance on a vertical comb is influenced by the Earth's magnetic field; the regularly small deviations in the dance disappear as the magnetic field is compensated to 4%. Fluctuations in the total intensity of about 1000 gamma influence the deviation; this is also the case if the bees are forced to change their dancing angle in relation to the lines of force of the magnetic field by turning the dancing platform around its vertical axis. Amplifications of the magnetic field up to 13 times the geomagnetic field result in a more pronounced dispersion regarding the indication of the direction. After compensation of the Earth's magnetic field, faultless dances were stated only after a period of readjustment. (Authors)

84. LUCA, L., O. ROSCA, N. CHITAN, and C. RUSU. 1967.
Influenta cimpului magnetica supra cresterii larvelor si a productiei de matase la *Bombyx mori*. [The influence of the magnetic field on the growth of the larvae and on silk production of *Bombyx mori*.]
Inst. Agron. Ion. Ionescu. Brad. Iasi. Lucr. Stint. 1967: 381-387.

Low-frequency and low-intensity pulsative magnetic fields affect the development of the larvae, and the cocoon production in *Bombyx mori*. Depending on the duration, intensity and the stages of application, the effect of these fields can be either stimulatory or inhibitory. 3 days after the start of incubation, the eggs and larvae were

subjected daily for 20 min. to the action of a 3.5 gauss magnetic field. This treatment brought about a 10% increase in silk output. (B.G.)

85. LUK'YANOVA, S.N. 1967.
O vliyanii postoyannogo magnitnogo polya na bioelektricheskiyu aktivnost' razlichnykh obrazovanii golovnogo mozga krolika. [Effect of a constant magnetic field on the bioelectrical activity of different formations of the rabbit brain.]
Zh. Vyssh. Nerv. Deyatel. Im. I. P. Pavlova 17(4):722-729.

Experiments on rabbits with chronically implanted electrodes have shown that the summated bioelectrical activity of the cortex and some subcortical formations (the hippocampus, the hypothalamus, specific and non-specific formations of the thalamus and the mid-brain reticular formation) of the rabbit brain changes under the action of a constant magnetic field of 460 oersted. Statistically significant changes of bioelectrical activity, observed in 66% of cases, were manifested in an increase in the number of spindles, slow waves, or pointed waves during the action of the magnetic field. The most intensive changes of bioelectrical activity were recorded in the hypothalamus and the cortex, and the least intensive in the mid-brain reticular formation. Injection of caffeine and adrenaline enhanced the reactions to the constant magnetic field, while nembutal and chlorpromazine weakened them. (Author)

86. MAJ, Z., and K. DUTCZAK. 1967.
The influence of the constant magnetic field on infectious properties of sap from potato virus X infected tobacco leaves.
Acta Biol. Cracov. Ser. Bot. 10(2):227-232.

Extracts were subjected to treatment with a constant magnetic field of 1600 oersted intensity. The effect was determined by counting the number of lesions formed by the treated samples on the inoculated tobacco leaves. The magnetization caused a partial inactivation of the infective sap. This inactivation was, however, not proportional to the length of exposure. No changes were observed either in the serological activity of the treated samples, in the character of primary lesions on the infected leaves, or in the length of the incubation period for the virus. (M.S.)

87. MAJ, Z., and K. DUTCZAK. 1970.
Studies on the effect of constant magnetic field on tobacco

mosaic virus synthesis in tobacco leaves.
Acta Microbiol. Pol. Ser. A Microbiol. Gen. 2(3):143-148.

The effects of 48- and 72-hr exposures to a constant magnetic field (1200 oersteds) on tobacco mosaic virus [TMV] were examined using an inoculum of isolated leaf discs of tobacco (*Nicotiana glutinosa* cv. White Burley). Homogenates obtained from discs after 48 hr. exposure to the magnetic field contained 38% less infective viruses in comparison with those exposed for 72 hr. Similar treatment on purified TMV *in vitro* gave no effects. (E.M.D.)

88. MARCINIAK, S. 1968.
Dzialanie pola magnetycznego na ustroj zywy. [Effects of the magnetic field on the living organism.]
Wiad. Lek. 21:947-949. 1 June.

A review of animal experiments has shown that exposure to magnetic rays can either retard growth completely (5500 Gauss), hinder development, reduce the size of offspring generally by 20% (2500 Gauss), induce abortions (4200 Gauss) or shorten considerably the life span of the offspring (3100 Gauss). Female mice proved more resistant to the deleterious effects of magnetic rays while males generally showed more marked developmental delays or died as a result of the exposure. Mature mice, however, could withstand homogeneous or heterogeneous magnetic ray exposure without manifesting any harmful effects. The body temperature of animals exposed to magnetic rays was approximately 1°C lower than that of controls. Pathological studies indicated that magnetic field induction prevented malignant transformation, even in cases where exposure did not inhibit growth of the primary induced neoplasm. (K.B.)

89. MIKHAILOVSKY, V.N., N.N. KRASNOGORSKY, K.S. VOICHISHIN, L.I. GRABAR, and V.N. AHEGAR. 1969.
Susceptibility of human subjects to weak magnetic fields.
Dopov. Akad. Nauk Ukr. RSR 31(10):929-933.

Susceptibility to very weak oscillations of the geomagnetic field range was shown experimentally in three of ten healthy male volunteers whose responsiveness to direct exposure was measured by changes in electroencephalographic recordings. One of the three subjects manifested the significant rhythmic changes together with increased pulse rate, breathing difficulties, pallor, and headache. The subjects' condition returned to normal once exposure to the magnetic field was terminated. In a second experiment a group of

ten patients, pre-selected because of the ease with which they could undergo hypnosis, were trained to exhibit a mental reflex at the beginning of somnolence when an acoustic signal of a certain frequency was sounded and awakened due to a sound of another frequency. The patients then attempted to develop a mental reflex for somnolence by exposure to the magnetic field which was shut on and off at various random intervals. Only three of the patients were able to develop such a mental reflex upon magnetic exposure and all three were considered subjectively healthy. (J.F.H.)

90. MIRO, L., and N. CHALAZONITIS. 1967.
Effets d'un champ magnetique constant et intense sur l'autoactivite du ventricule d'*Helix* en normothermie. [Effects of a strong constant magnetic field on the autoactivity of *Helix* in normothermia.]
Comp. Rend. Acad. Sci. (Paris), Ser. D. 161(5):1100-1105.

The effects of the magnetic field on the amplitude of the mechanogram depend essentially on the intially imposed diastolic tonus. In the majority of cases the amplitude increases when the tonus is moderate or weak. An initial excessive distention of the organ tends to minimize the effects of the field on the amplitude. If the initial diastolic tonus is very weak, inverse effects are often observed. The effects of the constant and uniform magnetic field seem to be equivalent to those of an electric current proceeding through either the pacemaker cells or the ensemble of contractile fibers. It is concluded that the continuous and uniform magnetic field modifies the transmembraneous currents responsible either for the frequency of the pacemakers or for the propagation of the excitation from one fiber to another. (A.R.T.)

91. MIRO, L., G. DELTOUR, and A. PFISTER. 1968.
Influence des variations d'un champ magnetique sur la croissance de certains micro-organismes. [Influence of magnetic field variations on the growth of certain organisms.]
In: AGARD Pattern Recognition. Body Armour and Aircrew Equipment Assemblies. Current Space Medical Problems. Aeromedical Evacuation. 25th Meeting of the Aerospace Medical Panel, London, 15-17 October 1968, Proceedings. Advisory Group for Aerospace Research and Development, Paris, France, C6-1 to C6-6.

In three series of experiments growing *Escherichia coli* cultures were exposed to varying levels of magnetic fields. In a magnetic field of 42,000 gauss, no appreciable change in growth rate was observed; however, when the field strength

was changed the metabolic output and growth rate increased in proportion to the number of viable cells counted. Daughter cells produced during this period were considered to be polynuclear and to have inferior nuclear structures to the mother bacteria. (M.H.E.)

92. MIRO, L. 1969
Biological effect of low magnetic field environments.
Techtran Corp., Glen Burnie, Md. 6 pages.
(transl. of Action biologique des ambiances a faible champ magnetique. p. 259-266. In: Association pour le Developpement des Sciences et Techniques de l'Environment, Journees Francaises de l'Environment, Ecole Nationale Superieure de l'Aeronatique, Paris, France, March, March 31-April 1, 1969, Proceedings. Paris, Association pour le Developpment des Sciences et Techniques de l'Environment. 1969).

The author tests the hypotheses that irradiation by cosmic rays in the absence of the protective geomagnetic field as well as direct action of low magnetic field can cause adverse biological effects. Tests are cited (physiological, visual, and psychological) which indicate no differences exist between the experimental and control subjects, whether animal, plant, or human. Only the critical threshold of fusion was significantly disturbed. In prolonged experiments on mice, however, loss of hair due to generalized hyperplasia was observed after four months, with premature death of the animals in four months to one year. Consideration of these results leads to the conclusion that additional long term experiments are needed. (Author)

93. MUELLER, W., and P. JITARIU. 1969.
Effect of variable magnetic field on the sodium permeability of isolated frog skin.
Rev. Roum. Biol. Ser. Zool. 14(4):273-277.

Experiments were carried out in 2 stages, during different seasons (the 1st stage-December 1967, the 2nd-April 19-June 7, 1968). Frogs were exposed to the variable magnetic field for 3 hours. With the December frogs Na permeability rose from 1.04 μ-equivalent in the control frogs to 1.78 μ-equivalent. With the April 19-June 7 frogs Na permeability also rose from 2.04 μ-equivalent in control frogs to 4.10 μ-equivalent in the frogs exposed to a variable magnetic field. The variable magnetic field led to a rise of Na permeability of isolated frog skin irrespective of season, and seemed to influence the cell metabolism of the ventral skin of frogs. (R.C.T.T.)

94. MUTSCHALL, V. 1969.
Biological effects of magnetic fields.
For. Sci. Bull. 5(2):13-36.

This review of Soviet research in magnetobiology embraces: consideration of physicochemical effects on animals, water, ionic solutions, blood constituents, and body metabolism; effects of steady state (static) and time variable (a-c induced) magnetic fields on animal specimens *in vitro*, including phagocytic function of the reticuloendothelial system, pathomorphological changes in the gastrointestinal tract and visual organ, hemo- and lymphodynamic disorders, and immunological reactions by the organism; effects of static magnetic fields on plant, fish, bird, rabbit, rat and mouse specimens *in vivo*, including growth, respiration, mitosis, conditioned reflexes, and bioelectric activity of various brain structures; and, effects of artificial magnetic fields on the human organism, including long-term (3 to 5 years) tolerance of exposure to magnetic fields varying from less than 350 to more than 5000 oersteds, occurrence of local, general, neurological, and functional disorders in the exposed workers, and relationship of human skin static electrical potential (SEP) to the degree of perturbation of heliogeomagnetic factors. (A.R.T.)

95. NEGOESCO, I., A. CONSTANTINESCO, M. DON, and C. HELTEANU. 1969.
Le stress et le transport des hormones thyroidiennes.
[Stress and the transport of thyroid hormones.]
Rev. Roum. Endocrinol. 6(3):215-220.

Data from the literature are cited to point up the conflict as to the mode of action of stress on the thyroid gland. In general, the studies undertaken use as thyroid tests: iodine uptake, histologic changes in the thyroid, the speed of loss of radioactive iodine from the thyroid, the basal metabolism, and the protein bound iodine (PBI). This study attempts to resolve problems relative to the influence of stress on thyroid function, using a reproducible stress method on animals (Wistar rats). Each day for 12 days the experimental animals were exposed to the stress of a discontinuous magnetic field for 2 minutes at 50 Herz followed immediately by 3 minutes at 100 Herz. Urinary adrenalin and noradrenalin levels were measured in 24 hour samples. Blood studies included determination of free thyroxin, PBI and counter-current paper electrophoresis assessment of thyroxin (tagged with radioactive iodine) in the protein fractions. Results are tabulated and show an augmentation of free thyroxin while at the same time there was a diminution of the thyroid hormone linked to

the albumin fraction; both modifications gave statistically significant figures. The absence of significant modification of the PBI showed that the most important change was at the peripheral level, in the equilibrium established between the free hormone and the hormone linked with the protein. (A.R.T.)

96. NEURATH, P.W. 1969.
The effect of high-gradient, high strength magnetic fields on the early embryonic development of frogs.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 177-187.

Test of the hypothesis that the effect of magnetic fields on the early development of an organism should affect particularly those cellular components of the organism which have a paramagnetic susceptibility larger than the rest of the tissue. In investigating magnetic-field effects on the early embryonic development of frogs, a special effort was made to detect connections between observed growth abnormalities and peculiar ferritin motions within the embryo, such as ferritin concentration gradients within cells. The investigation results brought no substantiation of the ferritin hypothesis though the embryonic development was affected in a highly significant manner. An alternate hypothesis and further experiments are suggested. (M.V.E.)

97. NIKULIN, A.V. 1969.
Vliyanie orientatsii levykh i pravykh plodov sakharnoi svekly v magnitnom pole zemli na nekotorye fiziologicheskie protsessy rastenii, razvivshikhsya iz nikh. [The effect of orientation of the left and right sugar beet fruits in the Earth's magnetic field on some physiological processes of plants developed from them.]
Izv. Akad. Nauk SSSR, Ser. Biol. 6:922-926.

In the course of experiments on the influence of the magnetic field of the Earth (MFE) on the growth and intensity of physiological processes of the progeny of the fruit of l- and d-bioforms it was noted that plants grown from the l- and d-fruit modifications displayed a different reaction to the MFE action. When the embryo root was oriented to the south pole the l-bioforms yielded plants characterized by higher growth rates. The progeny of such fruit displayed an increased catalase activity (by 19%), contained more chlorophyll (by 52%), showed a higher respiration rate (by 19%), and gave a higher (by 13%) and better yield (by 6%). The d-bioform progeny were characterized by a higher growth

rate (15-20%) and more intensive physiological processes (by 7-32%) if the plants were oriented towards the north pole. (M.K.)

98. NOVIKOVA, K.F., M.N. GNEVYSHEV, N.V. TOKAREVA, A.I. OL', and T.N. PANOV. 1968.
Vliyanie solnechnoi aktivnosti na vozniknovenie zabolevanii infarktom miokarda i smertnost' ot nego. [Effect of solar activity on the development of myocardial infarction and subsequent mortality.]
Kardiologiya 8(4):109-112.

Under consideration are 2324 authentic cases of myocardial infarction registered in the city of Sverdlovsk from 1961 till 1965, the resultant mortality rate, and instances of sudden deaths due to heart failures for 1944-1966 in relation to solar activity. The incidence of myocardial infarction and resulting lethality were significantly higher on magnetically active than on magnetically quiet days. A relationship between the frequency of sudden death and the 11-year cycle of solar activity is demonstrated. (Authors)

99. NOVITSKII, Yu.I. 1967.
Biomagnetism i zhizn' rasteniya. [Biomagnetism and plant life.]
Izv. Akad. Nauk SSSR, Ser. Biol. 2:257-261.

The effect of permanent magnetic fields, including low ones, is discussed. Exposure of plants to magnetic fields increases seed germination velocity and alters the gas exchange metabolic rates. The aftereffects of the exposure of plants to the magnetic field resulted in the disturbance of the cell division and growth, and in the change in velocity of protoplasmic movement. It is suggested that the cell sensitivity to low fields can be partially explained by the sensitivity of colloid structures to magnetic fields. It is emphasized that parallel studies of bioelectricity and biomagnetism should be performed. (Author)

100. PALMER, J.D. 1967.
Geomagnetism and animal orientation.
Natur. Hist. 76(9):54-57.

The migratory navigational abilities of several species of birds are discussed. Eyesight, memory, inborn ability to use the sun as a celestial guidepost, hereditary knowledge, and star-compass orientation are discussed. Experiments are cited that attempt to locate magnetoreceptors in animal

tissues. The author's experiments with *Volvox*, an aquatic alga, are described in detail. It was shown that the paths of *Volvox* emerging from an enclosure changed significantly in response to the presence and orientation of a magnetic field created by a nearby magnet placed either parallel to the Earth's field or at right angles to it. The response was an entirely behavioral one, not a physical attraction or repulsion of the alga by the magnetic field. Similar experiments by others using planarians and snails are discussed. (A.R.T.)

101. PAUTRIZEL, R., A. PRIORE, F. BERLUREAU, and A.-N. PAUTRIZEL. 1969.
Stimulation, par des moyens physiques, des defenses de la souris et du rat contre la trypanosomose experimentale. [Stimulation, by physical means, of the defenses in the mouse and in the rat against experimental trypanosomiasis.]
Comp. Rend. Acad. Sci. (Paris), Ser. D. 268(14):1889-1892.

The combined action of magnetic fields and electromagnetic waves have made it possible to keep alive mice infested with *Trypanosoma equiperdum* when control animals died on the 4th or 5th day following the infection. Using a new apparatus experiments were conducted to determine whether trypanosomiasis could be completely eradicated, and whether the immunological process is active in the parasitized animal. (A.C.S.)

102. PAVLOVICH, S.A. 1969.
Effect of magnetic fields on the sensitivity of bacteria to antibiotics.
Appl. Elec. Phen. 230-234. May-June.
(transl. of Elektronnaia Obrabotka Materialov, 76-81. May-June, 1969.)

Bacterial strains were subjected to subinoculations under the action of constant (H = 6000 Oe), varying (H = 180 Oe), and pulsed (H = 22,000 Oe) magnetic fields. The sensitivity of the bacteria to 11 antibiotics was determined. It was found that the sensitivity of bacteria to antibiotics after prolonged subinoculation in a magnetic field can either increase or decrease. It is thought that the observed changes were caused principally by differences in the specific characteristics of the bacteria tested. The 'magnetization' of the bacteria was usually accompanied by a decrease in sensitivity to antibiotics. The largest changes in sensitivity were usually noted for cultures subinoculated in the pulsed magnetic field. (G.R.)

103. PEREIRA, M.R., L.G. NUTINI, J.C. PARDON, and E.S. COOK. 1967.
Cellular respiration in intermittent magnetic fields.
Proc. Soc. Exp. Biol. Med. 124(2):573-576.

A microrespirometer at constant temperature (37 ± .01° C) was designed so that the specimen chamber remained between the poles of an electromagnet. The specimen was subjected to intermittent magnetic fields of 10-min. duration for a total of 2 hr., or 6 control and 6 experimental readings. In some experiments the periods were 20, 30 and 60 min. Field strength ranged from 40 to 10,000 gauss. Tissues were: ascites Sarcoma 37, embryo mouse kidney and liver, adult mouse kidney and liver (14-21 weeks old), neonatal mouse liver, HeLa cells (in limited experiments), and baker's yeast (*Saccharomyces cerevisiae*). Field strengths of 80 gauss or higher caused a 28.3 ± 2.6% ($p = .02$) depression of respiration of Sarcoma 37; of 85 gauss and above, a 29.3 ± 3.5% ($p < .05$) respiration depression of embryo kidney; of 80 gauss and above, a 20.6 ± 1% ($p = .01$) respiration depression of embryo and young neonatal (2-7 days) liver; and of 85 gauss and above, a 40.0 ± 5.0% ($p = .03$) stimulation of yeast repsiration. The respiration of adult kidney and of adult and older neonatal (8-11 days) liver was unaffected by any field strength. In 3 experiments with HeLa cells, fields of 80 gauss and above caused respiration depressions of 40 to 44%. A critical field strength of about 80-85 gauss existed for all effects observed; no effects were obtained below this strength, and increases produced effects of no greater magnitude. The effects were prompt and reversible. (Authors)

104. PERSINGER, M.A. 1969.
Open-field behavior in rats exposed prenatally to a low intensity-low frequency rotating magnetic field.
Develop. Psychobiol. 2(3):168-171.

Two experiments were conducted to study the behavioral effects of prenatal exposure to a low intensity, ultra-low-frequency magnetic field. In experiment 1, 117 albino rats that had been exposed continuously during their prenatal development to a 3 to 30 gauss, 0.5 Hz rotating magnetic field (RMF), and 83 control rats that had been exposed prenatally to control conditions, were tested in an open field at 21 to 25 days of age. RMF-exposed animals traversed significantly fewer squares than their controls in the open field ($p < .001$), but defecated significantly more in that situation ($p < .001$). RMF-exposed males also traversed significantly fewer squares than the RMF-exposed females ($p < .05$). Three RMF-exposed litters that were nursed by control

mothers did not differ significantly in open-field activity from the pups in the 4 RMF-exposed litters from which they were taken at birth. In Experiment 2, in which the experimenters did not know whether the subject was a RMF-exposed rat or a control rat, 19 RMF-exposed rats again traversed significantly fewer squares than the 20 control rats ($p < .01$). (K.B.)

105. PERSINGER, M.A., and W.S. FOSTER, IV. 1970.
ELF rotating magnetic fields: Prenatal exposure and adult behavior.
Arch. Meterol. Geophys. Bioklimatol. Ser. B. Klimatol. Bioklimatol. Strahlungsforsch. Climatol. Bioclimatol. Radiat. Res. 18(3/4):363-369.

In 3 separate experiments, adult male rats that had been exposed continuously during their prenatal development to a 0.5 Hz, 3-30 gauss rotating magnetic field (RMF), emitted significantly ($p < 0.01$) fewer lever presses in a free operant avoidance situation than rats that had been prenatally exposed to control conditions. This difference was apparently due in large part to the RMF-exposed rats' relatively low response rate within response bursts following a shock. However, RMF-exposed rats did not differ significantly from control rats in the number of shocks received. (K.B.)

106. PETRACCHI, G., A. CHECCUCCI, O. GAMBINI, and G. FALCONE. 1967.
Studies on bacterial growth: II. Effects of physical perturbations on bacterial growth.
Giorn. Microbiol. 15(3/4):189-196.

The possible action of a static magnetic field (3,000 Oe) on the development of static liquid cultures of *Escherichia coli* strain B was studied. Utilizing a very sensitive and reliable experimental device and a numerical procedure of analysis, no effect of the static magnetic field on bacterial growth could be demonstrated. However, some influences of a metallic shield on bacterial cultures were demonstrated. (A.R.)

107. PIRUZYAN, L.A., I.I. MARKUZE, and V.M. CHIBRIKIN. 1969.
Deistvie postoyannogo magnitnogo polya na astsitnuyu opukhol' Sarkomu 37. [The effect of a constant magnetic field on the ascitic tumor Sarcoma 37.]
Izv. Akad. Nauk SSSR, Ser. Biol. 6:893-898. Nov-Dec.

Maintaining mice in a constant magnetic field inhibits the development of the tumor process in them. The magnetic field reduces the accumulation of the volume of ascitic fluid and the number of tumor cells, and at the same time changes the concentration of free radical states. Linear dependence of the effect of inhibition regarding the criteria mentioned above on the magnetic field duration entitles one to suggest that the magnetic field influences directly the mechanism of development of the ascitic tumor process. (J.M.S.)

108. PIRUZYAN, L.A., M.A. ROZENFEL'D, V.M. GLEZER, and V.A. LOMONOSOV. 1969.
Microcalorimetry of the processes of coagulation in normal conditions and after exposure to a constant magnetic field.
Aerosp. Med. 40(10):1140-1141.

The action of a constant magnetic field leads to acceleration of the coagulatory process, accompanied by more intensive generation of heat. Thorough testing of this new, highly sensitive calorimetric method, capable of registering disturbances in the coagulatory system of the blood, will make possible its use as a new test in clinical and experimental applications.

109. PIRUZYAN, L.A., V.M. GLEZER, V.A. DEMENT'EV, V.A. LOMONOSOV, and V.M. CHIBRIKIN. 1970.
O mekhanizme biologicheskogo deistviia postoiannykh magnitnykh polei. [Mechanism of the biological action of constant magnetic fields.]
Akad. Nauk SSSR, Izv, Ser. Biol. p. 535-539. Jul-Aug.

Survey of recent research concerning possible mechanisms of biological action by a constant magnetic field. Magnetic field effects on the electrical properties of axons are analyzed, together with effects involving disturbance of the spatial orientation of biomolecules. Attention is given to mechanisms playing a role in the action of constant magnetic fields on electrolytes and liquids included in the composition of organisms. It is shown that the identification of the primary influence of constant magnetic fields in many of the observed biological effects requires further experimental and theoretical research. (T.M.)

110. PIRUZYAN, L.A., L.Kh. BARSEGYAN, O.M. MUKHORTOVA, G.S. SAVCHENKO, and V.M. CHIBRIKIN. 1971.
Effect of a constant magnetic field on the concentration of free radicals in the organs and tissues of mice.
Izv. Akad. Nauk SSSR, Ser. Biol. (1):128-134.

The concentration of free radicals in the organs of 60 mice of both sexes was followed after 4-, 24-, and 72-hr exposure to constant magnetic field at an intensity of 5000 Oe. The concentration of free radicals decreased in all organs except brain by 45-72% in 2-7 days after exposure. During the first 24 hr, the maximal change was proportional to the square root of the exposure time. After 72 hrs of exposure, the weight of the spleen increased while the weight of the liver and kidney was unchanged. Protein dystrophy, changes in cytoplasmic structure, and redistribution of the cytoplasm were found in the organs. (M.H.)

111. PITTMAN, U.J., and T.H. ANSTEY. 1967.
Magnetic treatment and seed orientation of single-harvest snap beans (*Phaseolus vulgaris L.*).
Proc. Amer. Soc. Hort. Sci. 91:310-314.

Subjecting dry bean seeds to a magnetic field of 1500 Oersteds for 240 hours and seeding with their micropylar end toward the geomagnetic north pole improved the total single-harvest snap bean yield and minimized the sieve-size distribution compared with the control. Provided that the decision concerning harvest data is corrected, returns from a snap bean enterprise can be improved by 25 to 50% over standard seed treatment and planting methods. (Authors)

112. PITTMAN, U.J., and D.P. ORMROD. 1970.
Physiological and chemical features of magnetically treated winter wheat seeds and resultant seedlings.
Can. J. Plant Sci. 50(3):211-217.

Seed of *Triticum aestivum* (wheat) cv Kharkov 22 MC magnetically treated before germination respired more slowly, released less heat energy, and grew faster during the initial 16 hours than similar but untreated seed. Magnetically treated seed absorbed more moisture and contained more reducing sugar during the initial 72 hours of growth than untreated seed. Addition of O to the seed environment during germination repressed shoot growth and enhanced root growth of magnetically treated wheat, but had no effect on untreated seed. Addition of CO_2 to the seedling environment suppressed the growth of shoots and roots of treated and untreated wheat seeds equally. (R.C.P.Z.)

113. PODSHIBIAKIN, A.K., R.V. SMIRNOV, T.G. UZHVA, and V.I. SHAKHOVA. 1967.
Priznaki sviazi mezhdu velichinoi fiziologicheskikh pokazatelei sostoianiia cheloveka i zhivotnykh i stepen'iu vozmu-

shchennosti magnitnogo polia zemli. [Indications of a relation between the magnitude of the physiological indices of the human and animal states and the degree of disturbance of the geomagnetic field.]
In: S.I. Subbotin, ed. Geophysics and Astronomy. Izdatel'stvo Naukova Dumka, Kiev. p. 209-213.

According to preliminary data, magnetic storms and sudden-commencement geomagnetic disturbances diminish the conditioned nutritional reflex in dogs and decrease the survival rate of dogs reanimated after an electric shock. It is also noted that fewer human subjects volunteer for tests during these periods. Most people exhibit certain effects, such as, a pronounced increase in the electrical potentials of the skin and in the asymmetry of their distribution, prior to the occurrence of a magnetic storm. (L.M.)

114. POKORNY, J., and V. JELINEK. 1967.
Investigations of the effect of combined electromagnetic fields on neoplastic malignant growth. A contribution to the problem. Neoplasma 14(5):479-485.

Mice with transplanted tumors (Kr2 ascites, S37 ascites, NK ascites tumors, and the HK adrenocarcinoma of the mammary gland) were exposed to the action of magnetic and electromagnetic fields of varying intensities. With certain arrangements of electromagnetic fields an inhibitory effect on the growth of the transplanted tumors was observed. It was reflected in a statistically significant prolongation of the survival times of the treated animals. (Authors)

115. POPESCU, C., E. ANDRONESCU, and M. TIBU. 1967.
Effect of magnetic fields on certain varieties of wheat. Bull. Inst. Politeh. Iasi 13(3-4):293-298.

The influence of magnetic fields on the germination of seeds and on the absorption of nutritive substances in the course of germination, growth, development, and production was investigated on autumnal wheat varieties. The magnetic field was applied at 2 intensities of 90 and 180 G. The seeds were exposed for 20 minutes daily over a period of 10 days. Some of the seeds were wetted afterwards for 48 hours with a solution containing ^{32}P, were washed, and the amount of ^{32}P penetration was determined. In some varieties like Ponca and 301 the ^{32}P absorption was increased by 10-27%, demonstrating faster development capacity in the 1st vegetation phases; in other varieties like Skorospelka 3, the modification was insignificant. The germinative energy (determined at 20-3°C) was increased by 5-33%, while the

germinative capacity increased 9%. The most favorably affected varieties were Belotzerkovskaya 198, Bezostaya 1, Ponca 301, and Funone; after 12 days the length of the roots of these varieties had increased by 6-70% over the untreated plants. Other improvements noted in these varieties were increases of stalk length, of ear length, of earlet number, and of grain harvest. (M.B.E.)

116. POUMAILLOUX, M. 1969.
Repercussions humaines de l'activite solaire interne.
[Human after-effects of internal solar activity.]
Cah. Coll. Med. Hop. Paris 10(15):1201-1214.

The multiplicity of effects provoked on the Earth by solar eruptions make it rational to measure these effects by measuring geomagnetic variations and their effects on terrestrial life in a manner more direct than the phases of the sun-spot cycles. Discussion of extraterrestrial electrical activity and biology includes consideration of influences upon the hematopoietic system, the neuro-endocrine system, and upon the coagulation and fibrinolysis of blood. Correlations between solar activity and pathologic manifestations in man are discussed. Correlations between solar activity and explosive outbreaks of mass violence in the northern hemisphere from 1778 to 1969 are shown in a table. It is concluded that this study should be considered as an outline to stimulate future research. (A.R.T.)

117. PRESMAN, A.S. 1970.
Electromagnetic fields and life.
Plenum Press, New York. 336 pages.

This monograph reviews the Russian and non-Russian literature dealing with biological influences of the electromagnetic spectrum from the superhigh radio frequencies to magnetic fields. Theoretical foundations for the effects of the phenomena are discussed in addition to the author's own general hypothesis in which it is postulated that electromagnetic fields serve as conveyors of information from the environment to the organism, within the organism and among organisms. Experimental investigations of the biological action of electromagnetic fields include: morphological changes in tissues and organs due to emf; neurohumoral regulation in the entire organism; reproduction and development of organisms; cellular and molecular level effects; and the regulatory effects of vital processes. The concepts and investigations offered by this monograph should be of interest to biologists and biophysicists, physicians, physiologists, physicists and radio engineers. (E.L.E.)

118. PUMPER, R.W., and J.M. BARNOTHY. 1969.
The effect of strong inhomogeneous magnetic fields on serum-free cell cultures.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 61-65.

An investigation of the effects of strong magnetic fields on serum-free cell cultures of rabbit myocardium and of mouse lung fibroblast isolates was carried out. It was found that in each case there was a significant increase in the growth rates of cells when exposed continuously for two to seven days to a static magnetic field of 14,600 Oe, with a 5000 Oe/cm gradient. Two exposures at lower field strength (7000 Oe) showed a decrease of cell growth. Pilot experiments with other cell lines showed that the sensitivity to a magnetic field varied greatly with cell type and with the age of the serial cultures. (L.M.)

119. RABINOVITCH, B., J.E. MALING, and M. WEISSBLUTH. 1967.
Enzyme-substrate reactions in very high magnetic fields. I.
Biophys. J. 7(5):187-204.

Within a 3% error, no detectable changes in the rate of 4 enzyme-substrate reactions were observed for periods of exposure of 20 min. in a magnetic field of up to 170,000 gauss. The enzymes tested were RNase, polyphenoloxidase, peroxidase, and aldolase. (M.L.)

120. RABINOVITCH, B., J.E. MALING, and M. WEISSBLUTH. 1967.
Enzyme-substrate reactions in very high magnetic fields. II.
Biophys. J. 7(4):319-327.

The effect of conditioning the enzyme trypsin in solution at pH 8.2 in a large magnetic field before determining its reactivity towards a synthetic substrate N-benzoyl DL-arginine p-nitroanilide (BAPA) was examined. This "pretreatment" was allowed to proceed for as long as 3-2/3 hours in a magnetic field of 208 kgauss at temperatures 26 and 36°C. No effect on reactivity was observed when such pretreated enzyme solutions were compared with identical but untreated enzyme solutions. A single such reaction, allowed to proceed directly in a magnetic field of 220 kgauss for 9 min, similarly showed no difference in rate from its control. (Authors)

121. RATNER, S.C., and J.W. JENNINGS. 1968.
Magnetic fields and orienting movements in mollusks.
J. Comp. Physiol. Psychol. 65:265-268. Apr.

The feeding structures, radulae, of six species of mollusks, including three of amphineura, two of snail, and one of limpet, were dissected and tested for responses to magnetic fields. The radulae of the amphineura, which are reported to contain magnetite, responded readily to above-normal magnetic fields; 59 live specimens of *Chaetopleura apiculata* were tested with magnetic fields ranging from normal to 8,000 gauss. Subjects moved more in normal magnetic fields than in above-normal fields. (A.I.)

122. RENO, V.R. 1969.
Conduction velocity in nerves exposed to a high magnetic field.
U.S. Nav. Aerosp. Med. Inst. (Pensacola) NAMI 1089. p. 1-13.
AD-699171

Action potentials were recorded at 4 positions from frog sciatic nerves exposed to a constant magnetic field of 11.6 kilo-oersted. External electrodes arranged in pairs on segments of nerves oriented both parallel and perpendicular to the field permitted conduction velocity measurements to be expressed as a function of field orientation. The increase in conduction velocity was observed to be orientation dependent, as was the appearance of the latent period. An after-effect was noted that persisted to the end of the experiments. Possible mechanisms of action of the field are discussed in terms of current theories of impulse propagation. (A.B.)

123. ROBERTS, A.M. 1970.
Motion of *Paramecium* in static electric and magnetic fields.
J. Theor. Biol. 27(1):97-106.

An elementary quantitative model, based on Jahn's "volume conductor" theory, is described to explain the motion of paramecia in static electric fields (galvanotaxis). An expression for the orientation sensitivity to electric fields in derived. The contraction and eventual bursting observed at high field strengths is attributed to the heating effect of the current flowing through the organism. Several authors have suggested that weak magnetic fields (of less than 1000 oersted) can influence the motion of *Paramecium*. The possibility of such an interaction is considered in the light of the simple model described. (A.B.)

124. ROSTKOWSKA, J., and W. MOSKWA. 1968.
The influence of a magnetic field on susceptibility for

toxic compounds in *Spirostomum ambiguum* Ehrb.
Acta. Protozool. 5(20):305-313.

Protozoa when placed for a prolonged time in a strong magnetic field, exhibit a higher susceptibility to the poisons applied in the experiment: Entobex, Enteroseptol, Dilombrine Salol. Morphological changes manifested in *Spirostomum* under the influence of the coupled action of magnetism and toxic compounds have been ascertained. (Authors)

125. RUSSELL, D.R. 1969.
Effect of a constant magnetic field on invertebrate neurons.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 227-232.

The primary objective of this study was to determine whether or not a magnetic field would affect the spontaneous activity of neurons located in the subesophageal ganglion of an invertebrate (the cockroach). The secondary objective was to determine the type and magnitude of the effect. Nerve impulses from 10 esophageal ganglia were anlayzed and are presented in a table. Statistical treatment of the data shows that the 6,600-Oe magnetic field caused a 17 to 27 percent inhibition in spontaneous firing rates. Possible mechanisms contributing to the inhibitory effect exhibited in these experiments are discussed. (A.R.T.)

126. RUSSELL, D.R., and H.G. HEDRICK. 1969.
Preference of mice to consume food and water in an environment of high magnetic field.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 233-239.

An apparatus is described that was used to study the activity and food-water intake of albino Swiss female mice influenced by a permanent magnetic field environment of either high (1,100 Oe) or low intensity. All 11 animals used in this study exhibited increased food and water intakes in the presence of the high magnetic field environment. Each animal was subjected to 4 different configurations of the apparatus for a period of 22 hours in each configuration. The results, given in a table, show that the animals spent a total of 2,130.8 minutes in the low and 1,839.5 minutes in the high magnetic field environment. As a measure of activity, the animals are recorded to have made 17,044 trips to the low and 20,241 trips to the high magnetic field en-

vironment. The results indicate that the animals showed a preference toward increased activity, as well as increased food and water intakes, in the presence of the high magnetic field environment. (A.R.T.)

127. SACHAVA, T.S., and L.E. SAMOKHVALOVA. 1970.
Ob izmenenii membrannogo potentsiala kletok vodorosli *Nitella flexilis* pri deystvii postoyannogo magnitnogo polya.
[Changes in the membrane potential of cells of the algal *Nitella flexilis* under the action of a steady magnetic field.]
Biofizika 15:89-92. Jan-Feb.

When a steady magnetic field with an intensity of 1,000, 1,600 or 4,500 oersteds was applied to *Nitella* cells with exposure times of 20, 30, and 60 minutes, and one day, statistically reliable ($p < 0.01$) reduction in the membrane potential was observed. After removal from the 1,000 Oe field, statistically reliable ($p < 0.05$; $p < 0.01$) restoration of the membrane potential occurred; full restoration of the membrane potential was not observed. After application of the 1,600 and 4,500 Oe steady magnetic fields, a tendency was noted toward restoration of the membrane potential to its initial level, but it was not statistically reliable ($p < 0.1$). The aftereffects following the 1,000 and 1,600 Oe magnetic fields were observed for 40 minutes following the 20 minute exposure, 30 minutes following the 30 minute exposure, 60 minutes following the 60 minute exposure and one day following the one day exposure. The aftereffects produced by the 4,500 Oe exposure were observed for one day, regardless of exposure time. (J.F.H.)

128. SCHOLANDER, P.E., and M. PEREZ. 1971.
Experiments on osmosis with magnetic fluid.
Proc. Nat. Acad. Sci. U.S. 68(6):1093-1094.

Experiments on a ferromagnetic colloidal fluid at equilibrium showed equality between magnetic and osmotic force; this result identifies solute pressure against the free surface as the cause of the negative solvent pressure. Except for water of hydration, there is no other osmotic interaction between solute and solvent. (K.B.)

129. SEIDEL, D. 1968.
Der existenzbereich elektrisch und magnetischinduktiv angeregter subjektiver lichterscheinungen (phosphene) in abhaengigkeit von aeusseren reizparametern. [The frequency range for the electrical and magnetic induction of subjective light patterns (phosphenes).]
Elektromedizin 13:194-211. Dec.

It is known that electrical stimulation of the human skull with rectangular current pulses induces a subjective observation of formless flickering light. With specified stimulus parameters (e.g. pulse frequency and repetition ratio), defined light patterns of abstract, geometrical figures, e.g., arcs, waves, lines can also be perceived. These patterns are called "phosphenes". In this paper it is shown that the range of the stimulus parameters in which phosphenes can be excited is determined by the current applied and the duration of and interval between the electrical pulses. In other experiments, the excitation frequency range for magnetically induced phosphenes was determined by stimulating the head with a sinusoidal alternating magnetic field from a toroidal coil. With both methods of excitation (electric and magnetic) the greater part of the induced patterns was perceived in the frequency range of 10 to 50 cps. The magnetic flux density most favorable for stimulation was in the range from 200 to 500 Gauss. The average number of induced phosphenes per subject was about 2 or 3 with electrical stimulation and 1 or 2 with magnetic stimulation. (modified author summary)

130. SIMMERS, M.H. 1967.
Growth of radish (*Raphanus sativus*) seedlings in magnetic fields.
Biol. Plant. (Praha) 9(5):377-382.

Radish seedlings were grown in asymmetric magnetic fields. The number of seeds germinated and the dry weight of the plants were the 2 criteria by which possible effects were examined. Two experiments were done; in the first the plants were grown for an average of 7.7 days and in the second for 14.1 days. A statistical analysis of the results failed to reveal any significant difference between control plants grown in dummy magnets and those subjected to the magnetic influence. (Author)

131. SOKOLOV, S.D. 1967.
Protivovospalitel'noe deistvie polya postoyannogo magnita.
[The anti-inflammatory action of a constant magnetic field.]
Patol. Fiziol. Eksp. Ter. 11(3):69-70.

There was no noticeable constriction of vessels in the burned ears of rabbits either during or after their subjection to a constant magnetic field. However, it did produce an anti-inflammatory effect. In the 1st day after burns and subsequently in the 15 day experiment it was apparent that the inflammatory reaction was considerably less marked in the

experimental group than in the control. This manifested itself in the reduced tendency to blistering, edema and necrosis of the tissues of the ear. (M.S.)

132. STEEN, H.B., and P. OFTEDAL. 1967.
Lack of effect of constant magnetic fields on *Drosophila* egg hatching time.
Experientia 23(10):814.

The effect of homogeneous magnetic fields of 1600 and 5000 Gauss on the egg hatching time of *Drosophila*-embryos was investigated (normal egg hatching time: 20 ± 0.5 hr.). No effect could be determined. (auth. sum. transl.)

133. STREKOVA, V.Yu., and D.M. SPITKOVSKII. 1971.
Analysis of possible damages of chromosome structure in a constant magnetic field simulated by condensed submolecular DNP-systems.
Fiziol. Rast. 18(1):192-196.

A heterogeneous magnetic field with an intensity of 12,000 oersted affected considerably the rheological properties of deoxyribonucleoprotein (DNP). A correlation was established between the reaction and the N/P ratio in the nucleoprotein preparation. At high values of N/P (4.6-4.9) relative relaxation of DNP structures in the magnetic field was less than in the control. At low values of N/P (3.7-4.2) it was higher. The amount of DNP thread contraction in solution with standard protein content (N/P ratio) increased in a magnetic field. These data suggest that one of the possible mechanisms of the effect of the magnetic field on mitosis consists in the interference with structure formation in the chromosome nucleoprotein compounds. (A.L.)

134. TARAKANOVA, C.A. 1968.
Deistvie i posledeistvie postoyannogo magnitnogo polya na dykhatel'nyi gazoobmen kornei *Vicia faba* L. [The action and aftereffect of a constant magnetic field on the respiratory gas exchange of the roots of *Vicia faba* L.]
Elektron. Obrab. Mater. 2:87-90.

The roots of Kuzminskie fodder beans were kept for 1 hr and 4 and 30 days in a magnetic field which was strong (4000 or 12,000 oersteds) or weak (20 oersteds). The brief action of the weak field did not exert any material action on the absorption of O_2 by the roots. However, a 30-day exposure reduced the O_2 absorption by 23%, reduced the liberation of CO_2 by 28%, and cut the respiratory coefficient by 6%. One

hr of exposure to a strong magnetic field also had no substantial effect on the respiration rate of the roots, and only when the magnetic field acted for a long time (4 and 30 days) was there 13-50% intensification of respiration. It is suggested that the effect evoking an intensification of respiration can be attributed to any reaction to stress, not the specific effect of the action of a magnetic field. (K.B.)

135. TARAKANOVA, G.A. 1968.
Fiziologo-biokhimicheskie izmeneniya prorostkov bobov v postoyannom magnitom pole. [Physiological-biochemical variations of seedlings of *Vicia faba* in a constant magnetic field.]
Fiziol. Rast. 15(3):450-456.

The effect of short and long duration magnetic fields of various intensity (20, 4000 and 12,000 Oe) on coupling of oxidative phosphorylation and on the growth of the roots of 1-30 day-old *Vicia faba* plants was studied. Weak (20 Oe) fields accelerated growth while strong fields (4000 and 12,000 Oe) inhibited growth. The stimulatory effect of dinitrophenol on respiration increased in weak magnetic fields and dropped in strong fields, regardless of the duration of action of the field. This could signify that the degree of coupling between oxidation and phosphorylation was higher in the 1st case and lower in the second. Short action (1 hr) of a 4000 Oe magnetic field also increased the coupling of oxidative phosphorylation. It is concluded that the pathologic changes in metabolism of plants located in a magnetic field develop gradually. They depend on the field strength and duration of action of the field on the plant. (M.K.)

136. TARAKHOVS'KYI, M.L., E.P. SAMBORS'KA, T.D. ZADOROZHNA, and E.M. LIKHTENSHTEIN. 1969.
Vplyv postiinoho mahnitnoho polya na perebih vahitnosti ta rozvytok potomstva u bilykh shchuriv. [Effect of constant magnetic field on the course of pregnancy and progeny development in white rats.]
Fiziol. Zh. Akad. Nauk Ukr. RSR 15(3):348-355.

When rats are affected with a constant magnetic field in the first 13 days of pregnancy decreases in the conception frequency, resorption, stillborn fetuses, and in some cases developmental abnormalities were found. Functional and morphological changes in ovaries as well as an increase in weight and hyperplasia of the adrenal cortical layer were found in females impregnated by males that were exposed to a constant magnetic field for a long time. A constant mag-

netic field has no negative effect on the development of progeny in the 1st generation. A negative gonadotropic and embryotropic effect was established in rats exposed to the prolonged effect of a weak constant magnetic field. (C.M.M.)

137. TEGENKAMP, T.R. 1969.
Mutagenic effects of magnetic fields on *Drosophila melanogaster*.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 189-206.

Several studies are reported on mutagenic effects of magnetic fields on *Drosophila*, primarily on sex ratios and the occurrence and transmission of new mutants. Deviations in sex ratios are related to differing magnetic field strengths, gradients, and durations of exposure time. It was shown that at the end of 3 generations both the low intensity, high gradient field and the 520 Oersted, low gradient field were significantly effective in altering the sex ratio in favor of male offspring. Magnetic fields of lesser or greater strength than that of the geomagnetic background, whether with low or high gradients, induce mutations affecting the sex ratios of *Drosophila melanogaster*. The mutagenic effects of magnetic fields on genes controlling traits unrelated to sex also have been demonstrated. It appears that only a few DNA synthesis fibrils are affected by the magnetic field, judging from the number of inbreeding generations required before the anomalies appear. (A.R.T.)

138. THIEMANN, W., and E. WAGNER. 1970.
Die Wirkung eines homogenen Magnetfeldes auf das Washstum von *Micrococcus denitrificans*. [The influence of homogeneous magnetic fields on the growth of *Micrococcus denitrificans*.]
Zeit. Naturforsch. Teil b, 25b:1020-1023. Sep.

The influence of strong homogeneous magnetic fields in the range of 5000 to 8000 gauss on the growth of *Saccharomyces cerevisiae* and *Micrococcus denitrificans* was studied. In the case of yeast growing under nearly anaerobic conditions an inhibition of growth rate was observed in the beginning of incubation, while some hours later the growth accelerated and surpassed the control. *M. denitrificans* on the other hand grew with the same rate as the controls during the first 2-3 hours of experiment; thereafter the magnetic field resulted in a significant acceleration of growth rate measured by a 5.8 to 13.3% increase of oxygen consumption after 5-6

hours. Until now only inhibition of bacterial growths by magnetic fields has been reported in the literature. (Author)

139. TODOROV, S.I., and M.R. RACHEVA. 1966/67.
Biologichno deistvie na magnitno pole vorkhy mitozata i khromozomite v korenovata meristema na *Vicia faba* L.
[Biological action of a magnetic field on the mitosis and the chromosomes in the radical meristem of *Vicia faba* L.]
God. Sofiiskiya Univ. Biol. Fak. Kn. 2. Bot. Mikrobiol. Fiziol. Biokhim. Rast. 61:225-237.

A variable magnetic field, having a magnetic induction of 2780 G at the poles and of 2300-2490 G measured at a distance between the poles of 70 mm, was used. The influence of the magnetic field (with 15 mm separating the poles) on mitosis and the chromosomes in the primary meristem of *Vicia faba* was measured after 0.5, 1.0, 1.5 and 2.0 hrs. of exposure. In other experiments, the effects of exposing the meristems to 6 and 24 hrs. of magnetized water was studied. A statistical decrease in mitotic activity was proportional to the length of time in the magnetic field. In magnetized water an increase in the mitotic index was seen after 6 hrs., but returned to normal by 24 hrs. Exposures of 1.5 and 2.0 hrs. increased chromosomal aberrations by 60.49 and 83.23% respectively. Magnetic water did not cause such aberrations. (Y.K.)

140. TODOROV, S.I., A.I. GORANOV, and Ts.M. GEMISCHEV. 1966/67.
Stimulatsionen biomagniten efekt pri deistvie na magnitno pole i magnetizirane voda vorkhu semena ot *Cucurbita maxima* Duch. [Stimulative biomagnetic effect under action of a magnetic field and of magnetized water upon the seeds of *Cucurbita maxima* Duch.]
God. Sofiiskiya Univ. Biol. Fak. Kn. 2. Bot. Mikrobiol. Fiziol. Biokhim. Rast. 61:239-250.

The effect of a magnetic field and of magnetized water was determined in dry seeds with an exposure of 0.5, 1.0, 2.0 and 4-hr intervals. Following the 2-hr exposure, a magnetic stimulative effect was found. The stimulation of growth of the root extended to 13.38% 120 hr after the magnetic action, and to 43.06% after 168 hr. The stimulative effect was characterized by an increase in absolute dry weight, activity of lipase, and the quality of absorption by the root system. (A.C.S.)

141. TOPALA, N.D., and O. AILIESEI. 1969.
Influence of electromagnetic fields on immunological reactions. Influence of homogeneous magnetic fields on phagocytosis in vitro..
Rev. Roum. Biol., Ser. Zool. 14(6):443-447.

Phagocytosis of *Staphylococcus aureus* cells by guinea pig peritoneal leukocytes was stimulated 37.9% by the presence of a homogeneous magnetic field of 6300 Oe. The magnetic field modifies the surface tension of the leukocytes by changing the orientation of the molecules in the superficial cytoplasm and by stimulating dehydrogenase activity, thereby releasing energy. (D.C.F.)

142. TOROPTSEV, I.V. 1968.
Morfologicheskaya kharakteristika biologicheskogo deistviya magnitnykh polei. [Morphological characteristics of the biological effect of magnetic fields (animals, guinea-pigs, frogs, fish).]
Arkh. Pztol. 30(3):3-12.

A literature survey on the biological action of magnetic fields and the results of experimental-morphological investigations are presented. As demonstrated, a direct magnetic field, 7000 oersted in intensity and an indirect one (50 cycles/sec), 200 oersted in intensity, possessed a marked biological effect. In a comparison of direct and indirect magnetic fields of equal exposure (6-1/2 hr), the indirect field proved to be more active. Direct and indirect magnetic fields proved to induce disturbances of hemodynamics and lymph circulation. Histological investigations demonstrated a paretic dilatation of capillaries, edema of the lungs and of the testicles. Dynamic investigations pointed to normalization of the morphological picture 30 days after the field action. The magnetic fields (direct and indirect) failed to depress the regeneration process. (K.M.E.)

143. TRAVKIN, M.P. 1969.
Life in a magnetic field.
National Lending Library for Science and Technology, Boston Spa, England. 16 pages. Jul.
(transl. of Khim. i Zhizn (USSR) 9:22-25. 1968)

The history of magnetobiological research is reviewed and observed effects of magnetic fields on living matter are briefly outlined. Emphasis is placed on: the effects of terrestrial magnetism on protoplasm movement in leaf cells; the effects of increased solar activity with intensified electromagnetic fields on epidermic eruptions on humans; and

low magnetic field induced disorientations in birds and grain growth directions. Prolonged action of magnetic field in simulated space conditions caused changes in blood composition of animals and produced conditioned reflexes in fish. The theory is projected that cross-linking of the biological water molecules under the influence of a magnetic field is the basis of its biological action through changing the orientation of the nuclear spin of hydrogen in the water molecule. Also described is a theory that attributes biological effects of a magnetic field to informational reaction of the external electromagnetic field with the living systems by means of the field generated by the organism itself. (G.G.)

144. TYURAEVA, A.A. 1967.
Lechenie perimennym magnitnym polem trofícheskikh yazv nizhnikh konechnostei i infitsirovannykh ran. [Alternating magnetic fields in the treatment of trophic ulcers of the lower extremities and infected wounds (human).]
Vop. Kurortol. Fizioter. Lech. Fizkul't. 32(1):48-50.

The regenerative process improved when treatment of wounds and trophic ulcers included use of a magnetic field. Treatment may also include bandaging (including casts) and the application of salves. In extensive trophic ulcers, where surgery is indicated, the magnetic field can be used preoperatively. The apparatus used is portable and simple. The magnetic field also has an analgesic effect. (auth. sum. transl.)

145. TZENG, C.-H., and H. HON-KAI. 1967.
Influence of a magnetic field on seed germination and activities of related enzymes.
Chung Kuo Nung Yeh Hua Hsueh Hui Chih 5(3-4):80-86.

The influence of a magnetic field on peanut germination and on the activities of some enzymes was investigated. Seeds were treated with a magnetic field of 400 gauss during the day for a total period of 48 hours. The whole seedling or the juice of its homogenate was analyzed. The seedling grown under a magnetic field grew faster and bigger than the control; the main energy source for germination of the former was carbohydrates and for the latter, lipids. In the magnetic field-treated samples there was: an increase of respiratory quotient; no change in respiration rate; and higher activities of pyruvic and lactic dehydrogenases. Anaerobiosis was an important feature of the metabolism of peanut seeds exposed to a magnetic field during germination. (P.P.L.)

146. UKOLOVA, M.A., E.B. KVAKINA, and G.Ya. CHERNYAVSKAYA. 1969.
Energy metabolism of the hypothalamic-hypophyseal brain zone in rats exposed to the antitumor effect of a magnetic field.
Vop. Onkol. 15(12):60-64.

Rats were subjected to 500-700 G magnetic field and indices of energy metabolism were determined in: rats subjected to magnetic field; rats with resorbed tumors after subjection to magnetic field; rats with tumors after subjection to magnetic field; rats with tumors without subjection to magnetic field; and, rats in which the tumor grew in spite of the effect of the magnetic field. The magnetic field effect was accompanied by an increase of intensity of tissue respiration in the hypothalamic-thalamic region of the brain of intact rats, those with resorbed tumors, but to a much lesser degree in tumorous animals unaffected by the magnetic field. The magnetic field increased free oxidation in intact rats. Rats with resorbed tumors showed increased levels of all oxidative processes, especially, an increase of macroergic compounds. When the magnetic fields were ineffective, the formation of macroergics was the same as in rats with resorbed tumors. The magnetic field increased glycolytic processes in intact rats while glycolysis level in rats with resorbed tumors remained at the level of rats with tumors. The magnetic field effect leading to resorption of tumors was accompanied by increased oxidative processes in the hypothalamus-thalamic region. (J.R.M.)

147. UKOLOVA, M.A., and E.B. KVAKINA. 1971.
The effect of magnetic fields on tumor growth.
Joint Publications Research Service, JPRS-52411, Washington, D.C. 6 pages. 17 Feb.
(transl. of Vop. Onkol. 16(2):88-91. 1970)

The effect of a weak magnetic field (MF) on tumors induced by 3-4 benzpyrene (sarcomas) and on the first generations of transplanted sarcomas obtained from the induced ones was studied. Experiments were conducted on 204 random bred rats and Wistar rats. The rats were subjected to the effect of the MF after the tumors reached an average size of 0.41 plus or minus 0.06. An alternating MF, created by a permanent bar magnet with an induction of 500-700 gauss, rotating (rate of 2 rmp) over the tumor or the animal's head, was applied for 15 minutes a day (every other day or daily). Adrenalin was injected in a series of cases simultaneously with the application of MF. Tests on rats with transplanted 'benzpyrene' sarcoma showed that MF in-

hibits the tumor growth up to complete resorption, during direct action on the tumor as well as during action on the animal's head. The antitumoral effect of MF was increased by adrenalin, only in those cases, where this effect was weak. (K.B.)

148. VALENTINUZZI, M., and T. VAZQUEZ. 1968.
Desarollo de cultivos de *Tetrahymena pyriformis*, en campo magnetico estatico homogeneo. [Development of cultures of *Tetrahymena pyriformis* in a homogeneous static magnetic field.]
An. Soc. Cient. Argentina 185(1/2):3-30.

Colonies cultivated in media of definite composition showed a smaller number of individuals when they were exposed to the action of a homogeneous static magnetic field for periods of 6 hr equally spaced within each 24 hr for a total of 72 hr (a total exposure of 18 hr). The field intensities used were from 2000 to 8000 oersteds. The differences in growth between the treated and the control cultures amounted to between 5 and 80%. (D.M.G.)

149. VAN NOSTRAN, F.E., R.J. REYNOLDS, and H.G. HEDRICK. 1967.
Effects of a high magnetic field at different osmotic pressures and temperatures on multiplication of *Saccharomyces cerevisiae*.
Appl. Microbiol. 15(3):561-563.

The application of a yeast as a biosystem for determining the effects of a high magnetic field and other physical phenomena was studied. Multiplication of *Saccharomyces cerevisiae* was observed during exposure to a magnetic field of 4600 gauss. Cell populations were determined at 24-, 48-, and 72-hr intervals, and possible interactions between the magnetic field and other environmental parameters, such as time, temperature, and osmotic pressure, were considered statistically. The main effect of the high magnetic field was a significant reduction of cell multiplication during each time interval. Significant interactions were found to occur between temperature and the magnetic field at 24 hr, and between temperature and osmotic pressure at each sampling interval. Synergistic effects of the magnetic field and osmotic pressure at both 28 and 38°C were nonsignificant. (Authors)

150. VILENCHIK, M.M. 1967.
Magnitnye effekty v biologii. [Magnetic effects in biology.]
Usp. Sovrem. Biol. 63(1):54-72.

This review summarizes the results of a large number of (mostly American) works on magnetic effects in biology. Most of the works included in the review are qualitative in nature. It was found in many investigations that the organism begins to react at a certain threshold value of field intensity, after which the effect is constant over a certain interval of intensity. Some works note a maximum in the effect at a certain "resonant" value of field intensity. Many data indicate that heterogeneous fields have a different influence on biological systems than homogeneous fields, sometimes even having opposite effects. Some of the contradictions in the works studied may have resulted from failure to include: all parameters of the magnetic field (direction of lines of force, field gradient, etc.) in the analysis; or the differences in sensitivity of biological objects to magnetic fields as has been indicated by studies of the agglutination of erythrocytes under the influence of various agglutinating antibodies, the activity of various types of cells in tissue cultures, etc. (J.F.H.)

151. VYALOV, A.M. 1967.
Magnitnyye polya kak faktor proizvodstvennoy sredy. [Magnetic fields as a factor in the industrial environment.]
Vestn. Akad. Med. Nauk SSSR 22(8):52-58.

The working conditions and physical conditions of operators working with magnetizing and demagnetizing devices and exposed to constant, variable and pulse-type magnetic fields have been studied at industrial enterprises in a number of cities. The workers were found to be subjected to actual magnetic fields varying from 3-5 oersteds for pulse-type apparatus to 150-350 oersteds near electromagnets when the safety rules are followed, or several times this level if the safety rules are not followed. Even persons working near permanent magnets are subjected to variable magnetic fields, due to the motions which they perform as they work. This results in the induction of electrical currents in the bodily fluids, particularly the blood. Other changes included edematous, pasty skin on the hands, hyperkeratosis of the palms, difficulty in moving finger joints, painful sensations in the distal portions of the hands, unpleasant sensations in the area of the heart, changes in heart tones, bradycardia or moderate tachycardia, reduced arterial pressure, asthenic vascular reactions, EKG changes, increased excitability and EEG changes, as well as changes in the biochemical indicators and morphological composition of the peripheral blood. The author recommends increasing magnetic field intensity of 700 oersteds at the hands, with a gradient of 10-20 oersted/cm, 300 oersteds at the trunk with a gradient of 5-20 oersted/cm. (J.F.H.)

152. WEHNER, R., and Th. LABHART. 1970.
Perception of the geomagnetic field in the fly *Drosophila melanogaster*.
Experientia 26(9):967-968.

Several species of insects of the orders Blattaria, Coleoptera, Diptera, Hymenoptera, and Isoptera have been shown to exhibit in their orientation patterns the influences of the direction of the magnetic field. The sensory mechanisms involved in the perception of magnetic fields are relatively unknown. Experiments with bees show the existence of an influence of the geomagnetic field on gravity perception. The apparatus is described by which this influence has been studied in fruit flies. The deviation of the negative geotactic courses of the flies from the zero-direction is shown in a table in which the record shows the lines of inclination (30° to the horizontal) ascending to the South, West, or East. When flies were allowed to run straight upwards in any celestial direction, a unimodal preference for a special direction could not be proved. Preference for special directions with reference to the geomagnetic field were tested on a horizontal plane in the absence of light and directed gravitational stimuli. Under these conditions the flies did not move on the plane. However, their resting positions were mainly oriented in the South-North and East-West directions. It is concluded that when running on a plane at an inclination of 30° to the horizontal, the flies showed a strongly marked negative geotactic orientation performance thus demonstrating the influence of the magnetic field on the direction of the geotactic orientation. (A.R.T.)

153. WERBER, M., R.M. SPARKS, and A.C. GOETZ. 1972.
The behavior of weakly electric fish (*Sternarchus albifrons*) in magnetic fields.
J. Gen. Psych. 86:3-13.

A pulsed magnetic field, varying in intensity from 10 to 20 gauss and in frequency from 200 cps above the fish's own frequency to 200 cps below it, was shown to elicit an approach response from *Sternarchus albifrons*. The fish showed a significant preference for the area between the magnetic coils positioned on either side of one arm of a T maze with the field on, as compared with the field off. Maximal responses occurred at frequency rates other than those of the fish in a pattern totally dissimilar to that with imposed current stimuli, indicating that response to a magnetic field involves more than simple sensitivity to induce current. (Authors)

154. WEVER, R. 1968.
Die wirkung schwacher elektro-magnetischer strahlung irdischen ursprunges auf die circadiane periodik des menschen. [The effect of weak terrestrial electro-magnetic radiation on the circadian periodicity of man.]
In: H. Buecker, ed. Extraterrestrial, Biophysics, Biology, and Space Medicine.
Johann-Wolfgang-Goethe-Univ., Frankfurt Am Main, West Germany. p. 259-266.

The circadian periodicity of human subjects was tested in two insulated underground bunkers, one of which was shielded against the effects of the static magnetic field. Individuals or groups were isolated in the two bunkers for periods from 3 to 6 weeks. During the period of isolation, all activities as well as temperature, urine samples, physiological, and psychological data were monitored. A tendency toward internal desynchronization was observed, and a relationship exists between activity and vegetative periodicity which appears to affect optimum performance. Recommendations are presented for the application of the findings to space travel. (Author)

155. WILTSCHKO, W. 1968.
Uber den einfluss statischer magnetfelder auf die zugorientierung der rotkehlchen (*Erithacus rubecula*). [On the influence of static magnetic fields on the migratory orientation of the robin (*Erithacus rubecula*).]
Z. Tierpsychol. 25:537-558. Aug.

Migratory orientation activity of 102 European robins was observed during 775 nights. Results indicated the following findings and conclusions: 1) a normal migratory direction was chosen without visual cues but in the presence of the Earth's normal magnetic field (0.41 oersted); 2) in artificial magnetic fields of about normal intensity, a change of the direction of magnetic North caused a corresponding change in migratory orientation activity; 3) in artificial magnetic fields of about double the normal intensity, movement of the birds was random or was not oriented in the direction of migration; 4) in rooms with less than the normal intensity of the Earth's magnetic field, the movement of the birds was also random; and 5) birds kept for 3 days or longer in a steel chamber with a field intensity of 0.14 oersted were able thereafter to orient in artificial fields having field intensities of 0.14, 0.30, and 0.41 oersted. (Author)

156. WINTERBERG, F. 1967.
Some theoretical considerations on the inhibition of tumor growth by ultrastrong magnetic fields.
Arch. Biochem. Biophys. 122(3):594-598.

The forces acting on the microstructure of a biological system were derived in a systematic way starting from Maxwell's stress tensor. With a magnetic field above 100 kilogauss and with a magnetic field gradient above 10 kilogauss/cm, the magnetic forces acting on a cell may become strong enough to disrupt cellular membranes and distort the ordered process of cellular division. Since cancer cells seem to have a smaller mechanical strength than normal cells, it might be possible to selectively damage cancer cells by this method. Strong magnetic fields can be most economically generated by a superconducting coil submerged in liquid He. A simple experiment in vitro with a tissue culture could test the theoretical predictions. (Author)

157. YOUNG, W. 1969.
Magnetic field and *in situ* acetylcholinesterase in the vagal heart system.
In: M.F. Barnothy, ed. Biological Effects of Magnetic Fields, Vol. 2.
Plenum Press, New York. p. 79-102.

Effects of magnetic fields on an *in situ* frog vagal heart preparation were studied. Fields of 2,700-17,000 Oe appeared to decrease the duration of vagal inhibition, to decrease cardiac contractility, and to lead to high frequencies of cardiac irregularity at high field strengths. Acetylcholinesterase activity (I) was apparently increased by low homogeneous magnetic fields. Inhomogeneous fields increased I in the early phase but caused arrhythmic contractions later. At low field strengths, inhibitors of I such as physostigmine reversed magnetic field effects. The most likely site of action of magnetic fields is thought to be I at the myoneural junction. (A.G.L.)

158. ZABOTIN, A.I. 1969.
Fotosintyez u magnitnom polye. [Photosynthesis in a magnetic field.]
In: I.A. Tarchevskii, ed. Funktsional 'nye Osobennosti Khloroplastov.
Kazan Universitet, Kazan, USSR. p. 91-95.

Photosynthesis in a magnetic field of 2-3 week old wheat plants grown in a greenhouse under natural illumination as a sand or as a water culture, with an addition of Knopp so-

lution, was studied by measuring the amount of assimilated CO_2, or by a decrease of $^{14}CO_2$ in an enclosed photosynthetic chamber. The ^{14}C redistribution among the products of photosynthesis after 15-minute exposure was determined by 2-dimensional paper chromatography and autoradiography. Upon exposure to a static magnetic field for 25-30 minutes, the photosynthetic intensity decreased by 15%. Exposure to a pulsating magnetic field had a similar effect. The exposures to magnetic fields decreased the formation of sucrose and hexoses, and increased the formation of phosphate ethers, amino acids (esp. alanine), organic acids (esp. malic acid), and high-polymer compounds, due to the considerable decrease in ATP formation. (J.S.)

159. ZHOKHOV, V.P., and E.I. INDEIKIN. 1970.
O svyazi ostrykh pristupov glaukomy s kolebaniyami magnitnogo polya zemli. [Relationship between acute attacks of glaucoma and changes in the magnetic field of the earth.]
Vestn. Oftalmol. 5:29-30.

The relationship between the incidence of acute attacks of glaucoma (1304 observations) and geomagnetic field fluctuations was studied. A direct dependence between the number of applications for medical help in connection with acute attacks of glaucoma and the planetary index of magnetic perturbation existed. Moreover, glaucomatous patients showed a statistically significant difference in mean values of the horizontal component of the geomagnetic field in the days with and without acute attacks. (S.B.)

160. ZOLYNEAK, C.C., and C. CAZACU. 1968.
Comportarea in cimp magnetic uniform si cu impulsuri rectangulare a formei diploide si autotetraploide de *Fagopyrum esculentum* Moench. [The behavior of diploid and autotetraploid forms of *Fagopyrum esculentum* Moench in a uniform mangetic field and with rectangular impulses.]
An. Stiint. Univ. A. I. Cuza Iasi, Sect. II (A) Biol. 14(2):257-261.

A uniform magnetic field with an intensity of 8-27 Oe and rectangular impulses with an intensity of 100-300 Oe had no genetic effect on *Fagopyrum* seeds. The magnetic fields stimulated lengthwise growth of roots and hypocotyls only at specific intensities. The time factor did not seem to cause an increase in stimulation. The effect of the magnetic field appeared to be on the performance and concentration of ions, thus producing changes in the permeability of the membranes and leading to alteration in the total energy potential and the general metabolism of the plant. (S.K.)

161. ZOLYNEAK, C.C. 1968.
Tratarea combinata cu raze gamma si cimpuri magnetice omogene a semintelor uscate de forma diploida si autotetraploida de *Lycopersicon esculentum* Mill. soiul 'Yellow pear-shaped.' [The combined treatment with gamma rays and homogeneous magnetic fields of dry diploid and autotetraploid seeds of *Lycopersicon esculentum* Mill. cv. 'Yellow pear-shaped.']
An. Stiint. Univ. A. I. Cuza Iasi, Sect. II (A) Biol. 14(2)-263-266.

Tests (growth of length of roots and hypocotyls, chromosomal aberrations of sprouts from dry seeds treated successively with gamma rays and magnetic fields) were carried out on 2 forms (2x=24, 4x=48). The homogeneous magnetic field decreased the inhibitory effect of the radiation, thus producing a modification in the spectrum of postirradiation effects. (A.B.C.)

SUBJECT INDEX

EXPOSURE, ⩽ 30 min. (continued)

EXPOSURE, > 30 min ⩽ 1 hr.

EXPOSURE, > 1 hr ⩽ 6 hrs

EXPOSURE, > 14 days ≤ 30 days (continued)

EXPOSURE, > 30 days ≤ 3 mos.

EXPOSURE, > 3 mos.

EXPOSURE, prenatal

FIELD STRENGTH, strong (continued)

FIELD STRENGTH, very strong

GEOMAGNETISM, magnetic variation

GEOMAGNETISM, shielded

HUMAN (continued)

IMMUNOLOGY

TAXIS, magnetic field (continued)

TEMPERATURE, body

TEMPERATURE, constant

TEMPERATURE EFFECT, magnetic field

AUTHOR INDEX

AUTHOR INDEX